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SIXTY-NINTH SESSION.

Monday, 1st December 1851.

DR CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. On the Total Eclipse of the Sun on 28th July 1851, observed at Göteborg ; with a description of a new Position Micrometer. By William Swan, Esq.

I observed the eclipse from a hill about a mile to the north of Göteborg, situated in latitude $57^{\circ} 43' 5''$, longitude $0^h 47^m 49^s$, in company with Mr Edward Lane, Advocate, who kindly rendered me his valuable assistance in making the observations for time. The telescope I used was furnished by Mr Adie of Edinburgh. It has a good object-glass, with an aperture of 2.1 inches, and about 31.5 inches focal length ; and the eye-piece employed in observing the eclipse magnified about 28 times. A dark glass, lent me by Professor Chevallier, consisting of a coloured prism achromatized by a prism of colourless glass, slid in a groove before the eye-piece, so as to admit of being instantly removed. This glass made the sun's image appear yellow, slightly tinged with green.

As considerable discrepancies occur in the positions assigned by different observers to the prominences seen at the eclipse of 1842,

I made use of a position micrometer, devised for the purpose of rapidly determining their places on the sun's limb. A circular plate of metal, 8 inches in diameter, was attached, by a collar passing through its centre, to the sliding tube of the telescope, to which it was firmly clamped, so as not to turn round. This plate was covered with a disc of card on the side next the eye-end of the telescope. Inside the tube carrying the plate, another tube carrying the eye-piece, slid smoothly, so as to admit of being freely turned round. The latter tube was furnished with two springy arms, pointing in opposite directions, in front of the plate, like the hands of a clock, and having steel points, by which holes could be pricked in the card disc. A small level was attached at right angles to one of these arms, and parallel to the card disc. In the eye-piece were fixed three equidistant parallel spider lines, the outer two being placed at an interval equal to the moon's apparent diameter calculated for the time of the total phase of the eclipse; so that when the outer wires were made to embrace the moon's disc, the middle wire would pass through its centre. The instrument was adjusted for observation, by causing the middle wire to coincide with a plumb-line, seen at a distance through the telescope; while, at the same time, the bubble of the level was brought to the middle of its tube by turning the arms, which were then securely clamped to the tube carrying the eye-piece. It is evident that if, after this adjustment, the bubble were again brought to the middle of the tube, while the outer wires were made to embrace the sun's disc, the middle wire would pass through its vertex; and two holes being pricked in the card, the line joining them would represent the sun's vertical diameter at the time of observation. If next, while the sun was kept between the outer wires, the middle wire was made to bisect any object at its limb, and holes were again pricked in the card, the angles between the lines joining the respective pairs of holes would measure the angular distance of the object from the sun's vertex. In this manner the positions of the red prominences, seen during the total phase of the eclipse, could be rapidly registered on the card, without ever removing the eye from the telescope.

The observations of time were made by means of a box chronometer by Adams of London, obligingly furnished by Lieutenant C. A. Pettersson, of the Navigation School of Göteborg. It was compared with his standard chronometer about 3^h 15^m before the com-

mencement of the eclipse, and again, the following day, after an interval of 24 hours.

The weather, which previously had a very unfavourable aspect, improved rapidly before the commencement of the eclipse. An extremely thin cirrous cloud, however, continued to overspread the sky; but this did not sensibly impair the definition of the sun, which was remarkably good until some time after the total phase, when the sky became more thickly clouded. During the progress of the eclipse the cusps continued quite sharp, until the sun was reduced to an extremely narrow crescent of about 90° or less, when they were sensibly rounded. This appearance became more and more decided, until at length the moon's limb was quickly joined to that of the sun by numerous thick lines, which occupied nearly all the remaining crescent of the sun. The spaces between the lines were at first rudely rectangular, but gradually became rounded so as to resemble a string of bright beads, after which they finally disappeared. The same phenomena were seen in a reverse order after the total phase, but the beads were not so numerous as before.

The moment Baily's beads were gone, I looked at the sun with the naked eye, and saw the corona fully formed. The darkness at first seemed great, owing to the contrast of the recent sunshine; and Mr Lane found it necessary to use a candle in reading the chronometer. The horizon, chiefly towards the north, was filled with light of a magnificent orange-yellow, or amber-colour, by which I had no difficulty in writing down the time of the commencement of the totality. It was a ghastly spectacle to behold—a black sun surrounded by a pallid halo of light, and suspended in a sky of sombre leaden hue; and there was so much to observe in the effects of the eclipse on the appearance of the landscape, that probably about 15^s elapsed before I looked again through the telescope, having previously removed the dark glass. The first object that attracted my attention was a remarkable hook-shaped red prominence, situated $110^\circ 30'$ to the west of the sun's vertex; and immediately afterwards I saw another prominence with a serrated top, resembling a chain of peaked mountains, which was situated a little below the first, $132^\circ 40'$ to the west of the sun's vertex. At the risk of offering what may be deemed a whimsical comparison, I can best describe the form of the hook-shaped prominence by saying it resembled the Eddystone or Bell Rock lighthouse, transferred to the sun, with its top beginning

to fuse and bend over, like a half-melted rod of glass. The prominences increased very sensibly in height during the progress of the total phase, until at length the hook-shaped one had attained an altitude which I estimated at rather more than $2'$. Both had remarkably definite outlines, and their forms were permanent so long as they remained visible; the only change being, that they increased in height, and became wider at the base, evidently owing to the moon's motion gradually disclosing those parts of them which were nearest to the sun's limb. They were of a full rose-tint, and were distinctly visible to the naked eye by the strong red tinge they imparted to the corona in their neighbourhood.

The corona cast no sensible shadow. To the naked eye, it appeared slightly tinged with pale purple or lavender colour, which, perhaps, was owing to the contrast of the strong yellow light in the horizon; for, when viewed through the telescope, it was silvery white. It was distinctly radiated, and shewed no trace of annular structure. The most striking feature it presented was the appearance of brilliant beams of light, which shone out in various directions. They were sharply defined, and brighter than the rest of the corona; and they were visible to some distance beyond its general outline. The most remarkable of these objects was a mass of light of a tolerably regular conoidal form, with its base towards the sun, and the curvature of its sides somewhat concave outwards, situated $28^{\circ} 30'$ to the east of the sun's vertex.

The first of the following Tables contains the observations, by means of the position micrometer, of the red prominences, and of the only spots visible near the sun's limb on the day of the eclipse, with the times of observation; the second, the times of the different phases of the eclipse as observed by me, and also Lieutenant Pettersson's observations of time, which he has kindly placed at my disposal; and the third, a series of thermometric observations. The latter were made by means of two small thermometers by Adie of Edinburgh, which were suspended in the shade. Their scales, by a recent comparison with his standard thermometer, were found correct to the tenth of a degree.

TABLE I.

Object Observed.	Time of Observation. Göteborg Mean Time.	Angle from Sun's Vertex.
Group of spots 1'.5 } from sun's limb, }	1 ^h 37 ^m	96° 30' West.
Single spot 1' from } sun's limb, . }	1 40	62 0 East.
Hook-shaped red } prominence, }	about 3 58	110 30 West.
Serrated prominence,	about 3 58	132 40 West.
Bright rays in corona,	about 3 58	28 30 East.

TABLE II.

	Observed by Messrs Swan and Lane in Lat. 57° 42' 57"·3, Long. 0 ^h 47 ^m 45 ^s ·2.	Observed by Lieutenant C. A. Pettersson, in Lat. 57° 42' 6"·2, Long. 0 ^h 47 ^m 51 ^s ·0.
Commencement of eclipse, . . .	2 ^h 53 ^m 4 ^s ·4 } (About 2 ^s too late.) }	2 ^h 53 ^m 3 ^s ·86
Beginning of totality,	3 55 52·6	{ 3 55 58·22 (Too late.)
End of totality, .	3 59 8·1	3 59 8·22
End of eclipse, . .	{ 4 57 57·8 (Possibly too late.)	4 58 2·59 (Difficult to observe.)

TABLE III.

Göt. Mean Time.	Dry Thermometer.	Wet Thermometer.
2 ^h 45 ^m	66°	60°
3 0	64	59
3 15	62	57·5
3 30	61	56·6
3 45	60	57
3 50	57·8	55·5
4 10	57	55
4 30	58·5	56
4 45	60	57
4 55	62·3	59·5
5 5	62	58·5
5 30	61	57·5

2. On the Total Solar Eclipse of July 28, 1851, as seen on the west coast of Norway. By Professor C. Piazzzi Smyth.

The author, who was in the party of Dr Robinson, Mr Alan Stevenson, and others, mentioned the very kind manner in which the Hydrographical Department had not only lent its instruments, but even caused them to be altered and adapted for the occasion, and also spoke of the liberal conduct of the Board of Northern Lights in conveying the observers to the station selected. This was on the Bue island, on the western coast of Norway, in lat. $61^{\circ} 9' 42''$, and long. E. $27^{\text{m}} 0^{\text{s}}$.

The arrangements were, however, defeated in a great measure by the cloudy state of the sky, which prevented any thing being seen of the sun or moon during or after the totality.

The instant of the commencement of the phenomenon was, however, observed, as well as an interesting case of an apparent repetition of it; and a good idea was obtained of the amount of personal and instrumental equation affecting the optical part only of the observations, and reaching, in this instance, the large quantity of 1^{m} and 50^{s} .

The darkness which came on at the same moment, was much more intense than would otherwise have been the case had the sky been clear. The heavens appeared all cloudy and black, except a small strip on the north horizon, which became of a lurid-red

colour. Except in that quarter, where some very distant mountain tops were visible out of the range of the moon's shadow, the land and sea were of a dark olive-green hue ; and the awful aspect of the whole was felt to be quite capable of producing those effects on ignorant men which history records ; while the Norse peasants about confirmed such a conclusion by their sudden and terrified flight.

3. On the Nature of the Red Prominences observed during a Total Solar Eclipse. By Professor C. Piazzi Smyth.

The author remarked, that the various observers who had seen the eclipse of 1842, gave such generally similar testimony of the place and the size of the red prominences as satisfactorily established them to be some celestial phenomenon. Then as to the question, whether they belong to the sun or the moon, the observers themselves were unanimous in the former view, and the red points then became flaming masses of fire some 40,000 miles in height.

The author, however, was by no means satisfied with the exactness of the proofs alleged ; he had tried experiments, suggested by Mr Nasmyth, for making the red points appear, if real, but without success ; and he further alluded to the different shapes given by the various observers to the same prominence, as rather militating against the idea of its being a large body at the distance of the sun.

On the other hand, if the red points be merely the light of the sun diffracted somehow at the moon's edge, the difference amongst observers at small distances on the earth's surface would be much more easily explained ; and he found that by introducing a small ball into the telescope when directed to the sun, and making it act similarly to the moon during the total eclipse, that very similar-looking points and tongues of pink flame could be produced.

He had not, however, yet been able to make the eclipsing-ball *occlude* the artificial pink prominences, and, therefore, would only attempt to establish that the solar existence of the points is only probable ; and that those who hold it to be proved, should contrive some means by which they may shew the said things in real being, without getting some moon, natural as in the eclipse, or artificial, as in the experiment, to stand in front of the sun, and act on its light by diffraction or otherwise.

4. Dr Traill then gave the following Notice of some of the recent Astronomical Discoveries of Mr Lassell, and exhibited an accurate lithograph by him of Saturn, with the recently-detected Dark Ring, &c. &c.

Mr William Lassell, of Starfield, near Liverpool, who has gained a high reputation by his admirable method of constructing large reflecting telescopes, has largely added to his scientific character within the present year (1851), by the discovery of an eighth satellite to Saturn, and determining its period of revolution; and also, by the detection of two new satellites of Uranus. This last discovery is thus announced by him in a letter in my possession:—

“ I have discovered two new satellites of Uranus. They are interior to the innermost of the two bright satellites discovered by Sir William Herschel, and generally known as the second and fourth. It would appear, that they are also *interior* to Sir William Herschel's first satellite, to which he assigns a period of revolution of about five days and twenty-one hours—(but which satellite I have as yet been unable to recognise.)

“ I first saw these two, of which I now communicate the discovery, on the 24th of October, and had then little doubt that they would prove satellites. I obtained further observations of them on the 28th and 30th of October, and also last night; and find, that for so short an interval, the observations are well satisfied by a period of revolution of almost exactly four days for the outermost, and two and a half days for the closest. They are very faint objects—certainly have not the brightness of the two conspicuous ones, but all four were, last night, steadily visible, in the quieter moments of the air, with a magnifying power of 778 on my 20 feet reflector.”—November 3, 1851.

It is well known, that the noble instrument here alluded to is the work of the hands of this eminent astronomer. Its focal distance is 20 feet. The great mirror is 2 feet in diameter, $2\frac{3}{16}$ inches in thickness, and weighs 420 lb. Mr Lassell's method of obviating the flexure of the mirror by its own weight, when resting on its edge, is exceedingly ingenious. A series of twenty-seven screws, arranged in triplets in three-armed iron plates, thus \therefore , press against the back of the mirror, so as to keep its true figure unchanged by position. Nothing can exceed the perfection of the metallic composition, and

the beauty of the polish. I may add, that for attaining a true parabolic figure in the grinding, Mr Lassell employs a beautiful mechanism of his own invention, which is put in motion by a small one-horse-power steam-engine. The *powers* which he uses with this fine instrument, are,—

For planets, from 300 to 800.

For fixed stars, from 600 to 1200.

For double and triple stars, from 1200 to 1800.

The following Donations to the Library were announced :—

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. Tweede Versameling, 7 Deel, 4to.—*From the Society.*

An Essay Explanatory of the Tempest Prognosticator, in the building of the Great Exhibition for the Works of Industry of all Nations. By George Merryweather, M.D. 8vo.—*From the Author.*

Letters to a Candid Inquirer on Animal Magnetism. By W. Gregory, M.D. 12mo.—*From the Author.*

Flora Batava. 165 Aflevering. 4to.—*From the King of Holland.*

Astronomical Observations made at the Radcliffe Observatory, Oxford, in the year 1848. By M. J. Johnson. Vol. IX. 8vo.—*From the Radcliffe Trustees.*

Astronomical Observations made at the Radcliffe Observatory, Oxford, in the year 1849. By M. J. Johnson. Vol. X. 8vo.—*From the Radcliffe Trustees.*

Proceedings of the Zoological Society of London, 1835, 1836, 1837, 1838, 1840, 1841, 1844, 1845, 1846. 8vo.—*From the Society.*

Reduction of the Observations of Planets, made at the Royal Observatory, Greenwich, from 1750 to 1830, under the Superintendence of G. B. Airy, Esq. 4to.

Reduction of the Observations of the Moon, made at the Royal Observatory, Greenwich, from 1750 to 1830, under the Superintendence of G. B. Airy, Esq. 2 vols. 4to.

Catalogue of 2156 Stars, formed from the Observations made during the twelve years from 1836 to 1847, at the Royal Observatory, Greenwich. 4to.

- Results of the Observations made at the Royal Observatory, Greenwich, 1847, 1848, 1849. 4to.—*From the Observatory.*
- Results of the Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, 1848 and 1849. 4to.
- Description of the Instruments and Process used in the Photographic Self-Registration of the Magnetical and Meteorological Instruments, at the Royal Observatory, Greenwich. 4to.
- Account of Improvements in Chronometers, made by Mr John J. Giffe. 4to.—*From the Royal Observatory.*
- Papers and Proceedings of the Royal Society of Van Diemen's Land. Vol. I., Parts 1 and 2. 8vo.—*From the Society.*
- Astronomische Beobachtungen auf der Königl. Universitäts Sternwarte in Königsberg :—herausgegeben von H. L. Busch. Abtheil. 23. Fol.—*From the Observatory.*
- Abhandlungen der Königl. Gesellschaft der Wissenschaften zu Göttingen. Band. 4. 4to.—*From the Society.*
- Nachrichten von der Georg-Augusts Universität und der Königl. Gesellschaft der Wissenschaften zu Göttingen, 1850, Nos. 1–17. 12mo.—*From the Society.*
- Beiträge zur Metallurgischen Krystallkunde. Von J. F. L. Hausmann. 4to.—*From the Author.*
- Handbuch der Mineralogie. Von J. F. L. Hausmann. 1er. Theil. 8vo.—*From the Author.*
- Plan and Description of the Original Electro-Magnetic Telegraph. By W. Alexander, Esq. 8vo.—*From the Author.*
- Minutes of Proceedings of the Institution of Civil Engineers, containing Abstracts of the Papers and of the Conversations. Vol. I.–VIII. (1837–50.) 8vo.
- Catalogue of the Library of the Institution of Civil Engineers. 8vo.—*From the Institution.*
- Journal of the Statistical Society of London. Vol. XIV., Part 2. 8vo.—*From the Society.*
- Journal of the Horticultural Society of London. Vols. I., II., III., IV., V., and VI. Parts 2 and 3. 8vo.—*From the Society.*
- Notice sur les Altitudes du Mont Blanc et du Mont Rose, déterminées par des Mesures Barométriques et Géodésiques. Par M. le Commandant Deleros. 8vo.—*From the Author.*
- The American Journal of Science and Arts. 2d Series. Vol. II. No. 33. 8vo.—*From the Editors.*

Journal of the Asiatic Society of Bengal. Nos. 217 and 218. 8vo.
—*From the Society.*

Archives du Muséum d'Histoire Naturelle, publiées par les Professeurs-Administrateurs de cet Etablissement. Tom. V., Liv. 1 & 2 (Paris.) 4to.—*From the Museum.*

Quarterly Journal of the Chemical Society, No. 14. 8vo.—*From the Society.*

Verzangenheit und Zunkunft der Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. Von Dr C. G. Nees v. Esenbeck. 4to.—*From the Author.*

Compendium der Popularen Mechanik und Maschinenlehre. Von Adam Ritter von Burg. 8vo.

Compendium der Höheren Mathematik. Von Adam Ritter von Burg. 8vo.

Ueber die von dem Civil. Ingénieur Herrn Kohn, angestellten Versuche um den Einfluss oft wiederholter Torsionen auf den Molekularzustand des Schmiedeeisens auszumitteln. Von A. von Burg. 8vo.

Programm für die Ordentlichen und Ausserordentlichen Vorlesungen welche am K. K. Polytechnischen Institute zu Wien im Studienjahre. 1850-51. Staat finden werden. Von A. von Burg. 4to.

Kupffertafeln zum Compendium des Populären Mechanik und Maschinenlehre. Von A. von Burg. 4to.—*From the Author.*

Eighteenth Annual Report of the Royal Cornwall Polytechnic Society. 1850. 8vo.—*From the Society.*

Théorie Mathématique des Oscillations des Baromètre, et recherches de la loi de la variation moyenne de la Température avec la Latitude. Par M. E. Liais. 8vo.—*From the Author.*

Astronomical Observations, made during the year 1846, at the National Observatory, Washington. Vol. II. 4to.—*From the Observatory.*

Annales de l'Observatoire Physique Central de Russie, publiées par A. T. Kupffer. 1847. Nos. 1 and 2. 4to. *From the Observatory.*

Memorias de la Real Academia de Ciencias de Madrid. Tomo 1º, 1ª Partie. 4to.—*From the Academy.*

- Resumen de las Actas de la Academia Real de Ciencias de Madrid, en al año Academico de 1849 & 1850. 8vo.—*From the Academy.*
- Contributions to Astronomy and Geodesy. By Thomas Maclear, Esq., F.R.A.S. 4to.—*From the Author.*
- Verhandelingen der Eerste Klasse van het Koninklijk-Nederlandsche Instituut van Wetenschappen, Letterkunde, en Schoone Kunsten te Amsterdam. 3th Reeks, 4th Deel. 4to.
- Tijdschrift voor de Wis-En Natuurkundige Wetenschappen, uitgegeven door de Eerste Klasse van het Koninklijk-Nederlandsche Instituut van Wetenschappen, Letterkunde, en Schoone Kunsten te Amsterdam. 4th Deel. 8vo.—*From the Institute.*
- Memoirs of the Royal Astronomical Society. Vol. XIX. 4to.—*From the Society.*
- Transactions of the Microscopical Society of London. Vol. III., Parts 1 and 2. 8vo.—*From the Society.*
- Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. N.S. No. 34. 8vo.—*From the Society.*
- Journal of the Statistical Society of London. Vol. XIV., Part 2. 8vo. *From the Society.*
- Quarterly Journal of the Chemical Society. No. 15. 8vo.—*From the Society.*
- Papers and Proceedings of the Royal Society of Van Diemen's Land. Vol. I., Part 3. 8vo.—*From the Society.*
- American Journal of Science and Arts. Vol. XII., Nos. 34 and 35. 8vo.—*From the Editors.*
- Journal of the Asiatic Society of Bengal. N.S. No. 45. 8vo.—*From the Society.*
- Proceedings of the Liverpool Literary and Philosophical Society. Sessions 38 and 39. No. 6. 8vo.—*From the Society.*
- Archives du Muséum d'Histoire Naturelle, publiées par les Professeurs-Administrateurs de cet Etablissement. Tom. V., 3me Liv. 4to.
- Muséum d'Histoire Naturelle de Paris. Catalogue Méthodique de la Collection des Reptiles. 1re Liv. 8vo.
- Catalogue de la Collection Entomologique. Classe des In-

- sectes ordre Coléoptères. 1^{re} et 2^{me} Liv. 8vo. *From the Museum.*
- Transactions of the Linnæan Society. Vol. XX., Parts 2 and 3. 4to.
- Proceedings of Do. Do. Nos. 41, 42, 43, 44. 8vo.
- List of Fellows of Do. Do. 1850. 4to.—*From the Society.*
- Bericht über die in Jahren 1848 und 1849 auf den Stationen des Meteorologischen Instituts in Preussischen Staate angestellten Beobachtungen. Von H. W. Dove. Fol.—*From the Author.*
- Observations made at the Magnetical and Meteorological Observatory at the Cape of Good Hope. Vol. I., Magnetical Observations, 1841 to 1846. 4to.—*From the British Government.*
- Journal of the Horticultural Society of London. Vol. VI., Part 4. 8vo, and a List of Members.—*From the Society.*
- Journal of the Asiatic Society of Bengal, 1851. No. 4. 8vo.—*From the Society.*
- Mémoires de l'Académie Impériale des Sciences de St Pétersbourg. VI^{me} Serie. Sciences Mathématiques, Physiques et Naturelles. Tom. 6^{me}, 1^{re} Partie. Sciences Mathématiques et Physiques. Tom. IV^{me} Liv. 3 and 4. 4to.
- Mémoires présentés à l'Académie Impériale des Sciences de St Pétersbourg, par divers Savants et les dans ses Assemblées. Tom. VI^{me}, Liv. 5 & 6. 4to.—*From the Academy.*
- Observations faites à Nigré-Taguisk (Monts Oural), Gouvernement de Perm. Années 1848 et 1849. (1850.) 8vo.—*From the Observatory.*
- Proceedings of the American Philosophical Society. Vol. V., Nos. 45 and 46. 8vo.—*From the Society.*
- Mémoires sur le Digitaline, par MM. Homolle et Quevenne. 8vo. (2 copies).—*From the Authors.*
- On the Silurian Rocks of the South of Scotland. By Sir Roderick I. Murchison. 8vo.—*From the Author.*
- Three Letters to the Inhabitants of Ceylon, on the Advantages of Vaccination. By John Kinnis, M.D. 8vo.
- Contributions to the Military Medical Statistics of China. By John Kinnis, M.D.—On the Military Stations, Barracks, and Hospital of Hong Kong (written in 1846). On the Health of

H. M. and Hon. E. I. Company's Troops serving in China, from 1st April 1845 to 31st March 1846. 8vo.

Contributions to the Military Medical Statistics of the Bombay Presidency, 1851. By John Kinnis, M.D. 8vo.—*From the Author.*

Proceedings of the Geological Society of London. Vol. IV., Nos. 99, 101, 102, 103. 8vo.

Quarterly Journal of the Geological Society of London. Nos. 21, 22, 23, 24, 25, 26, 27, 28. 8vo.—*From the Society.*

Papers relating to the University of Sydney, and to the University College, Sydney, New South Wales. Printed at the desire of Sir J. F. W. Herschel, Bart., G. B. Airy, Esq., Professor Malden, and Henry Denison, Esq. 1851. 8vo.—*From the Editors.*

Journal of the Asiatic Society of Bengal. Nos. 208 to 210. Oct. to Dec. 1849. 8vo.—*From the Society.*

Proceedings of the Royal Astronomical Society. Vol. XI., No. 9. 8vo.—*From the Society.*

Monday, 15th December.

SIR DAVID BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read :—

1. On the Centrifugal Theory of Elasticity, and its connection with the Theory of Heat. By W. J. M. Rankine, Esq., C.E.

This paper contains investigations founded on the supposition, that that part of the elasticity of bodies which depends upon heat, arises from the centrifugal force of the revolutions of the particles of elastic atmospheres surrounding nuclei or atomic centres. The author has laid before this Society and the British Association several papers founded on this supposition, which he has elsewhere termed the hypothesis of molecular vortices.

The author's previous investigations were confined to atoms in which the particles of the elastic atmospheres might, without sensible error, be treated in calculation as being distributed in concentric spherical layers round their nuclei or centres, each layer being of equal density throughout, and having its particles throughout in a similar

state of motion. It might be doubted, therefore, whether the conclusions arrived at were applicable to any substances except gases, or very limpid liquids, in which the mutual actions of the atoms are similar in all directions.

To remedy this defect the present paper has been prepared, in which no definite supposition is made respecting the arrangement of the atomic centres, the distribution of their atmospheres, or the form of the orbits which the particles of those atmospheres describe. If the hypothesis, therefore, is a sound one, the conclusions are applicable to all substances. It will be seen that they are all consistent, and for the most part identical with those deduced from the more limited supposition. The most important are the following:—

Let Q denote the mechanical value of the quantity of heat, that is to say, the mechanical power corresponding to the vis-viva of the molecular revolutions, in unity of weight of a substance. Let h be the specific elasticity of the atomic atmosphere of the substance; k , a specific constant depending on the nature of the substance; τ , its absolute temperature as measured by a perfect-gas thermometer, and reckoned from a point $274^{\circ}6$ centigrade $= 494^{\circ}28$ Fahrenheit, below the temperature of melting ice; and α , a constant depending on the thermometric scale, and the same for all substances in nature. Then

$$\tau = \alpha \left(\frac{2Q}{hk} + 1 \right)$$

$\frac{hk}{2\alpha}$ is the *real specific heat* of the substance.

The *expansive pressure* of any body is composed of two parts; one depending jointly on density and heat, the other a function of density alone. Let P be the total expansive pressure, p the part depending jointly on density and heat, and V the volume of unity of weight of the substances, so that $\frac{1}{V}$ is its mean density. Then

$$P = p + f(V)$$

Let μ be the weight of the atmospheric part of an atom; M , the total weight; G_1 , a certain function of the density; and G'_1 , G''_1 , &c., the successive differential co-efficients of that function with respect to the hyperbolic logarithm of V . Also let

$$H_1 = \frac{\alpha G_1}{\tau} - \frac{\alpha^2 G'_1}{\tau^2} + \frac{\alpha^3 G''_1}{\tau^3} - \&c., \text{ ad. inf.}$$

Then

$$p = \frac{h \mu G_1}{M V H_1}$$

This formula was successfully applied in a previous paper, to the representation of M. Regnault's experiments on the expansion of gases, the co-efficients being determined empirically.

If the substance is in the state of perfect gas,

$$P = p = \frac{h \mu \tau}{\kappa M V}$$

Let V_0 be the volume of unity of weight of any substance in the state of perfect gas, under unity of pressure, at some fixed absolute temperature τ_0 . Then

$$\frac{h \mu}{\kappa M} = \frac{V_0}{\tau_0}$$

The foregoing are the principal conclusions arrived at in the first section of the paper, which treats of the relations between heat and expansive pressure.

The second section treats of the relations between heat and expansive power.

Let the indefinitely small quantity of heat which must be communicated to unity of weight of a substance, to produce the variation of temperature $\delta \tau$, simultaneously with the variation of volume δV , be denoted by

$$\delta . Q = \delta Q + \delta Q'$$

δQ being the portion which remains in the body as *sensible heat*, being directly employed in increasing the velocity of the molecular revolutions, and $\delta Q'$, the variation of *latent heat*, being that which is transformed into expansive power and molecular action, in altering the form and sizes of the orbits of the revolving particles. Then

$$\delta Q = \frac{h k}{2 \kappa} . \delta \tau$$

$$\begin{aligned} \delta Q' = \delta \tau . (\tau - \kappa) & \left(\frac{h \mu}{M \tau^2} + \int \frac{d^2 p}{d \tau^2} d V \right) \\ & + \delta V . (\tau - \kappa) \frac{d p}{d \tau} \end{aligned}$$

The integral being so taken as to be $= 0$ for the state of perfect gas.

Those two equations comprehend the whole theory of the mechanical action of heat, and agree with those given in the author's previous paper on that subject. In that paper the assistance of *Joule's Law* was used in investigating the second equation; in the present paper it is deduced directly from the hypothesis. The following are some of its consequences.

Let $P \delta V$ be the expansive power given out by the body while the variations $\delta \tau$ and δV take place. Then

$$\delta Q + \delta Q^1 - P \delta V = \delta \Psi(V, \tau)$$

is the exact variation of a function of τ and V . This is the mathematical expression of *Joule's Law*.

Let unity of weight of a substance be brought from the volume V_0 , and absolute temperature τ_0 , by the process (a), to the volume V_1 and absolute temperature τ_1 , and restored to the original volume and temperature by the *reverse* of the process (b). Let τ_a and τ_b be a pair of temperatures in the two processes, corresponding to the same value of $\int \frac{dp}{d\tau} dV$. The result of the pair of processes will be the transformation of a certain quantity of heat into expansive power, whose value is as follows:—

$$\int_{V_0}^{V_1} P dV (a) - \int_{V_0}^{V_1} P dV (b) = \int_{V_0}^{V_1} (\tau_a - \tau_b) \frac{dp}{d\tau} dV.$$

This equation comprehends as a particular case, *Carnot's Law* of the effect of machines working by expansion.

The following equation, hitherto known for perfect gases only, is shewn to be true for all fluids. Let a denote the velocity of sound in a fluid; K_v and K_p the specific heats at constant volume and constant pressure; then,

$$a = \sqrt{\left(g \cdot \frac{dP}{d \cdot \frac{1}{V}} \cdot \frac{K_p}{K_v} \right)}$$

2. On the Computation of the Specific Heat of Liquid Water at various Temperatures, from the Experiments of M. Regnault. By W. J. Macquorn Rankine.

The experiments of M. Regnault having been made by introducing water at a high temperature from a boiler into a calorimeter, containing water at a low temperature, and power exercised by the steam in the boiler in expelling the water was converted into heat by fluid friction, thus producing a rise of temperature in the calorimeter, for which allowance ought to be made in calculating the specific heat of liquid water from each experiment. Mr Joule's determination of the dynamical value of the specific heat of liquid water at low temperatures affords the means of calculating the correction required in each case.

The author of this paper having thus corrected several of the results computed by M. Regnault, shews that they agree nearly with this empirical formula :—

$$\frac{K}{K_0} = 1 + \alpha (T - T_0)^2$$

Where K is the specific heat of liquid water at the temperature T of an air thermometer, K_0 its specific heat at T_0 , the temperature of its maximum density (which is 4.1° centigrade, or 39.4° Fahr.) and α , a constant coefficient, whose values are—

For the centigrade scale,	.	.	0.000001
For Fahrenheit's scale,	.	.	0.000000309

The paper is illustrated by three tables: the first shewing the correction of M. Regnault's results; the second exhibiting a comparison between the experiments and the formula, and the third giving the results of the formula for every tenth degree of the centigrade scale, from 0° to 260° .

3. On the Quantities of Mechanical Energy contained in a Fluid Mass, in different states, as to Temperature and Density. By Professor William Thomson.

Let p be the pressure of a fluid mass when its volume and temperature are v and t respectively, and let $M dv + N dt$ be the

quantity of heat that must be supplied to it to augment its volume by $d v$ and its temperature by $d t$. The mechanical value of the work done upon it to produce this change is the excess of the mechanical value of the quantity of heat that has to be added above that of the work done by the fluid in expanding, and is therefore

$$J (M d v + N d t) - p d v.$$

It was shewn in the author's paper on the Dynamical Theory of Heat, that this expression is the differential of a function of v and t , so that, if this function be denoted by ϕ , we have,—

$$\phi (v, t) = \int \{ (JM - p) d v + N d t \}$$

This function would, if the constant of integration were properly assigned, express the *absolute quantity of mechanical energy contained in the fluid mass*. Failing an *absolute* determination of the constant, we may regard the function ϕ as expressing the mechanical value of the whole agency required to bring the fluid mass from a specified *zero* state to the state of occupying the volume v and being at the temperature t . In the present paper some formulæ are given, by means of which it is shewn that nearly all the physical properties of a fluid may be deduced from a table of the values of ϕ for all values of v and t ; and experimental methods connected with the experimental researches proposed in the author's last paper, are suggested for determining values of ϕ for a gaseous fluid mass.

4. On a Mechanical Theory of Thermo-Electric Currents. By Professor William Thomson.

It was discovered by Peltier that heat is absorbed at a surface of contact of bismuth and antimony in a compound metallic conductor, when electricity traverses it from the bismuth to the antimony, and that heat is generated when electricity traverses it in the contrary direction. This fact, taken in connection with Joule's law of the electrical generation of heat in a homogeneous metallic conductor, suggests the following assumption, which is the foundation of the theory at present laid before the Royal Society.

When electricity passes in a current of uniform strength γ through a heterogeneous linear conductor, no part of which is permitted to

vary in temperature, the heat generated in a given time is expressible by the formula

$$A \gamma + B \gamma^2$$

where A , which may be either positive or negative, and B , which is essentially positive, denote quantities independent of γ .

The fundamental equations of the theory are the following :—

$$F \gamma = J \left(\gamma \sum \alpha_t + B \gamma^2 \right) \quad . \quad . \quad . \quad . \quad . \quad (a)$$

$$\sum \alpha_t = \sum \alpha_t \left(1 - \epsilon^{-\frac{1}{J} \int_T^t \mu dt} \right) \quad . \quad . \quad . \quad . \quad . \quad (b)$$

where F denotes the electromotive force (considered as of the same sign with γ , when it acts in the direction of the current) which must act to produce or to permit the current γ to circulate uniformly through the conductor ; J the mechanical equivalent of the thermal unit ; $\alpha_t \gamma$ the quantity of heat evolved in the unit of time in all parts of the conductor which are at the temperature t when γ is infinitely small ; μ "Carnot's function"* of the temperature t ; T the temperature of the coldest part of the circuit ; and \sum a summation including all parts of the circuit.

The first of these equations is a mere expression of the equivalence, according to the principles established by Joule, of the work, $F \gamma$,† done in a unit of time by the electromotive force, to the heat developed, which, in the circumstances, is the sole effect produced. The second is a consequence of the first and of the following equation :—

$$\phi \cdot \gamma = \mu \sum \alpha_t \gamma \cdot (t - T) \quad . \quad . \quad . \quad . \quad . \quad (c)$$

where ϕ denotes the electromotive force when γ is infinitely small, and when the temperatures in all parts of the circuit are infinitely nearly equal. This latter equation is an expression, for the present circumstances, of the proposition‡ (first enunciated by Carnot, and first established in the dynamical theory by Clausius) that

* The values of this function, calculated from Regnault's observations, and the hypothesis that the density of saturated steam follows the "gaseous laws," for every degree of temperature from 0° to 230° cent., are shewn in Table I. of the author's "Account of Carnot's Theory," *Transactions*, vol. xvi., p. 541.

† See *Philosophical Magazine*, Dec. 1851, "On Applications of the Principle of Mechanical Effect," &c.

‡ "Dynamical Theory of Heat" (*Transactions*, vol. xx., part ii.) Prop. II., &c.

the obtaining of mechanical effect from heat, by means of a perfectly reversible arrangement, depends in a definite manner on the transmission of a certain quantity of heat from one body to another at a lower temperature. There is a degree of uncertainty in the present application of this principle, on account of the conduction of heat that must necessarily go on from the hotter to the colder parts of the circuit; an agency which is not reversed when the direction of the current is changed. As it cannot be shewn that the thermal effect of this agency is infinitely small, compared with that of the electric current, unless γ be so large that the term $B \gamma^2$, expressing the thermal effect of another irreversible agency, cannot be neglected, the conditions required for the application of Carnot and Clausius's principle, according to the demonstrations of it which have been already given, are not completely fulfilled: the author therefore considers that at present this part of the theory requires experimental verification.

1. A first application of the theory is to the case of antimony and bismuth; and it is shewn that the fact discovered by Seebeck is, according to equation (c), a consequence of the more recent discovery of Peltier referred to above,—a partial verification of the only doubtful part of the theory being thus afforded.

2. If $\Theta \gamma$ denote the quantity of heat evolved, [or $-\Theta \gamma$ the quantity absorbed] at the surface of separation of two metals in a compound circuit, by the passage of a current of electricity of strength γ across it, when the temperature t is kept constant; and if ϕ denote the electromotive force produced in the same circuit by keeping the two junctions at temperatures t and t' , which differ from one another by an infinitely small amount, the magnitude of this force is given by the equation

$$\phi = \Theta \mu (t' - t) \quad . \quad . \quad . \quad . \quad . \quad (d)$$

and its direction is such, that a current produced by it would cause the absorption of heat at the hotter junction, and the evolution of heat at the colder. A complete experimental verification of this conclusion would fully establish the theory.

3. If a current of electricity, passing from hot to cold, or from cold to hot, in the same metal produced the same thermal effects; that is, if no term of $\Sigma \alpha_t$ depended upon variation of temperature from point to point of the same metal; we should have, by equation (a)

$$\varphi = J \frac{d\Theta}{dt} (t' - t); \text{ and therefore, by (d), } \frac{d\Theta}{dt} = \frac{1}{J} \Theta \mu.$$

From this we deduce

$$\Theta = \Theta_0 \epsilon^{\frac{1}{J} \int_0^t \mu dt}; \text{ and } \varphi = (t' - t) \mu \Theta_0 \epsilon^{\frac{1}{J} \int_0^t \mu dt}$$

A table of the values of $\frac{\varphi}{\Theta_0 (t' - t)}$ for every tenth degree from 0 to 230 is given, according to the values of μ ,* used in the author's previous papers; shewing, that if the hypothesis just mentioned were true, the thermal electromotive force corresponding to a given very small difference of temperatures, would, for the same two metals, increase very slowly, as the mean absolute temperature is raised. Or, if Mayer's hypothesis, which leads to the expression $\frac{JE}{1 + Et}$ for μ , were true, the electromotive force of the same pair of metals would be the same, for the same difference of temperatures, whatever be the absolute temperatures. Whether the values of μ previously found were correct or not, it would follow, from the preceding expression for φ , that the electro-motive force of a thermo-electric pair is subject to the same law of variation, with the temperatures of the two junctions, whatever be the metals of which it is composed. This result being at variance with known facts, the hypothesis on which it is founded must be false; and the author arrives at the remarkable conclusion, that *an electric current produces different thermal effects, according as it passes from hot to cold, or from cold to hot, in the same metal.*

4. If $\mathfrak{D} (t' - t)$ be taken to denote the value of the part of $\Sigma \alpha_t$ which depends on this circumstance, and which corresponds to all parts of the circuit of which the temperatures lie within an infinitely small range t to t' ; the equations to be substituted for the preceding are,

$$\varphi = J \frac{d\Theta}{dt} (t' - t) + J \mathfrak{D} (t' - t) \quad . \quad . \quad . \quad (e)$$

and therefore, by (d)

$$\frac{d\Theta}{dt} + \mathfrak{D} = \frac{1}{J} \Theta \mu \quad . \quad . \quad . \quad . \quad (f)$$

5. The following expressions for F, the electromotive force in a

* The unit of force adopted in magnetic and electro-magnetic researches, being that force which, acting on a unit of matter, generates a unit of velocity in the unit of time, the values of μ and J used in this paper are obtained by multiplying the values used in the author's former papers; by 32.2.

thermo-electric pair, with the two junctions at temperatures S and T differing by any finite amount, are then established in terms of the preceding notations, with the addition of suffixes to denote the particular values of Θ for the temperatures of the junctions.

$$\left. \begin{aligned} F &= \int_T^S \mu \Theta dt = J \left\{ \Theta_S - \Theta_T + \int_T^S \mathfrak{S} dt \right\} \\ &= J \left\{ \Theta_S \left(1 - \epsilon^{-\frac{1}{J} \int_T^S \mu dt} \right) + \int_T^S \mathfrak{S} \left(1 - \epsilon^{-\frac{1}{J} \int_T^t \mu dt} \right) dt \right\} \end{aligned} \right\} (g)$$

6. It has been shewn by Magnus, that no sensible electromotive force is produced by keeping the different parts of a circuit of one homogeneous metal at different temperatures, however different their sections may be. It is concluded that for this case $\mathfrak{S} = 0$; and therefore that, for a thermo-electric element of two metals, we must have,—

$$\mathfrak{S} = \Psi_1(t) - \Psi_2(t)$$

where Ψ_1 and Ψ_2 denote functions depending solely on the qualities of the two metals, and expressing the thermal effects of a current passing through a conductor of either metal, kept at different uniform temperatures in different parts. Thus, with reference to the metal to which Ψ_1 corresponds, if a current of strength γ pass through a conductor consisting of it, the quantity of heat *absorbed* in any infinitely small part PP' is $\Psi_1(t) (t' - t) \gamma$, if t and t' be the temperatures at P and P' respectively, and if the current be in the direction from P to P' . An application to the case of copper and iron is made, in which it is shewn that, if Ψ_1 , and Ψ_2 refer to these metals respectively, if S be a certain temperature defined below (which, according to Regnault's observations, cannot differ much from 240° cent.), and if T be any lower temperature; we have

$$\int_T^S \{ \Psi_1(t) - \Psi_2(t) \} dt = \Theta_T + \frac{1}{J} F,$$

since the experiments made by Becquerel lead to the conclusion, that at a certain high temperature iron and copper change their places in the thermo-electric series (a conclusion which the author has experimentally verified), and if this temperature be denoted by S , we must consequently have $\Theta^S = 0$.

The quantities denoted by Θ_T and F in the preceding equation being both positive, it is concluded that, *when a thermo-electric current passes through a piece of iron from one end kept at about 240° cent., to the other end kept cold, in a circuit of which the remainder is copper, including a long resistance wire of uniform temperature throughout or an electro-magnetic engine raising weights, there is heat evolved at the cold junction of the copper and iron, and (no heat being either absorbed or evolved at the hot junction) there must be a quantity of heat absorbed on the whole in the rest of the circuit. When there is no engine raising weights, in the circuit, the sum of the quantities evolved, at the cold junction, and generated in the "resistance wire," is equal to the quantity absorbed on the whole in the other parts of the circuit. When there is an engine in the circuit, the sum of the heat evolved at the cold junction and the thermal equivalent of the weights raised, is equal to the quantity of heat absorbed on the whole in all the circuit except the cold junction.*

7. An application of the theory to the case of a circuit consisting of several different metals, shews that if

$$\varphi(A, B), \varphi(B, C), \varphi(C, D), \dots \varphi(Z, A)$$

denote the electromotive forces in single elements, consisting respectively of different metals taken in order, with the same absolute temperatures of the junctions in each element, we have

$$\varphi(A, B) + \varphi(B, C) + \varphi(C, D) \dots + \varphi(Z, A) = 0,$$

which expresses a proposition, the truth of which was first pointed out and experimentally verified by Becquerel. A curious experimental verification of this proposition (so far as regards the signs of the terms of the preceding equation) was made by the author, with reference to certain specimens of platinum wire, and iron and copper wires. He had observed that the platinum wire, with iron wires bent round its ends, constituted a less powerful thermo-electric element than an iron wire with copper wires bent round its ends, for temperatures within atmospheric limits. He tried, in consequence, the platinum wire with copper wires bent round its ends, and connected with the ends of a galvanometer coil; and he found that, with temperatures within atmospheric limits, a current passed from the copper to the platinum through the hot junction, and concluded that, in the thermo-electric series

$$\begin{array}{c} + \\ \text{Antimony, Iron, } \left\{ \begin{array}{l} \text{Copper,} \\ \text{Platinum,} \end{array} \right\} \text{Bismuth,} \\ - \end{array}$$

this platinum wire must, at ordinary temperatures, be between iron and copper. He found that the platinum wire retained the same properties after having been heated in a spirit-lamp and cooled again ; but with temperatures above some limit itself considerably below that of boiling water, he found that the iron and platinum constituted a more powerful thermo-electric element than the iron and copper ; and he verified that for such temperatures, in the platinum and copper element the current was from the platinum to the copper through the hot junction, and therefore that the copper now lay between the iron and the platinum of the series, or in the position in which other observers have generally found copper to lie with reference to platinum. A second somewhat thinner platinum wire was found to lie invariably on the negative side of copper, for all temperatures above the freezing point ; but a third, still thinner, possessed the same property as the first, although in a less marked degree, as the superior limit of the range of temperatures for which it was positive towards copper was lower than in the case of the first wire. By making an element of the first and third platinum wire, it was found that the former was positive towards the latter, as was to be expected.

In conclusion, various objects of experimental research regarding thermo-electric forces and currents are pointed out, and methods of experimenting are suggested. It is pointed out that, failing direct data, the absolute value of the electromotive force in an element of copper and bismuth, with its two junctions kept at the temperatures 0° and 100° cent., may be estimated indirectly from Pouillet's comparison of the strength of the current it sends through a copper wire 20 metres long and 1 millimetre in diameter, with the strength of a current decomposing water at an observed rate ; by means of determinations by Weber, and of others, of the specific resistance of copper and the electro-chemical equivalent of water, in absolute units. The specific resistances of different specimens of copper having been found to differ considerably from one another, it is impossible, without experiments on the individual wire used by M. Pouillet, to determine with much accuracy the absolute resistance of his circuit, but the author has estimated it on the hypothesis that the specific resistance of its substance is $2\frac{1}{4}$ British units. Taking $\cdot 02$ as the electro-chemical equivalent of water in British absolute units, the author has thus found 16300 as the electromotive force of an element of copper and bismuth, with the two junctions at 0° and 100° respectively.

About 154 of such elements would be required to produce the same electromotive force as a single cell of Daniell's; if, in Daniell's battery, the whole chemical action were electrically efficient. A battery of 1000 copper and bismuth elements, with the two sets of junctions at 0° and 100° cent., employed to work a galvanic engine, if the resistance in the whole circuit be equivalent to that of a copper wire of about 100 feet long and about one-eighth of an inch in diameter, and if the engine be allowed to move at such a rate as by inductive reaction to diminish the strength of the current to the half of what it is when the engine is at rest, would produce mechanical effect at the rate of about one-fifth of a horse-power. The electromotive force of a copper and bismuth element, with its two junctions at 0° and 1° , being found by Pouillet to be about $\frac{1}{100}$ of the electromotive force when the junctions are at 0° and 100° , must be about 163. The value of Θ_0 for copper and bismuth, according to these results (and to the value 160.16 of μ at 0°), or the quantity of heat absorbed in a second of time by a current of unit strength in passing from bismuth to copper, when the temperature is kept at 0° , is $\frac{163}{160.16}$, or very nearly equal to the quantity required to raise the temperature of a grain of water from 0° to 1° cent.

Monday, 5th January 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in
the Chair.

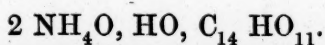
The following Communications were read:—

1. On the Absolute Intensity of Interfering Light. By Professor Stokes. Communicated by Professor Kelland.

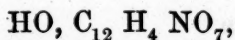
In this communication Professor Stokes described a method which he had discovered, by which he could express, mathematically, the absolute intensity of interfering light, as in the case of the images found in the focus of a telescope pointed to a star, and having a grating over the object-glass. The result was the same as that previously aimed at by Professor Kelland, but the mode of getting at it was shorter.

2. On Meconic Acid, and some of its Derivatives. By Mr Henry How. Communicated by Dr T. Anderson.

The author commenced his paper by observing that it formed a sequel to one communicated to the Society last Session on comenic acid; his object in the present instance having been partly to ascertain whether some of the substances described in his former paper could not be derived from meconic acid, which is the parent acid of comenic acid. This he shewed to be the case; but before detailing these experiments, he gave his process for purifying meconic acid, which is that of Gregory, modified by the use of ammonia instead of potass. Some grounds for preference of this plan were offered, and the composition of the salt obtained in the process was shewn to be

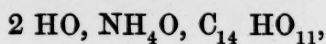


It is a salt crystallising from hot water in groupes of needles; is not decomposed at the heat of boiling water by itself, but when kept long at this temperature, in presence of ammonia, it produces the comenamic acid,



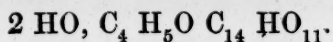
formerly described by the author as a product of the decomposition of comenate of ammonia in the same manner.

The action of chlorine on this salt gave rise, in the first place, to another acid salt of ammonia and meconic acid,



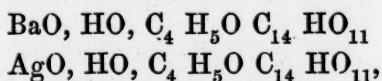
and, as a further product, chlorocomenic acid was isolated. Bromine gave with meconic acid bromocomenic acid; three experiments shewing that meconic acid itself yields no substitution products, its molecule splitting into carbonic acid, and the above-mentioned derivatives of comenic acid.

The action of hydrochloric acid gas on solution of meconic acid in alcohol was next gone into; and it appears that three products are formed, their relative proportions depending on the amount of gas employed, and the strength of the alcohol. They are all ethers. The first is the ethylomeconic acid, represented by the formula

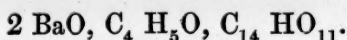


It is a crystalline substance, soluble in water, alcohol, and ether; fusible at 316° Fahr. to a yellow fluid. It is possessed of acid properties, and is indeed bibasic, forming two series of salts; this was

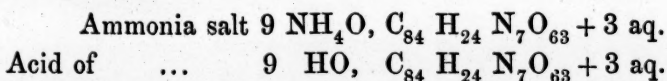
shewn by the description and analyses of two acid salts, the baryta and silver salts, whose composition is thus expressed,



and a neutral baryta salt, of the constitution,

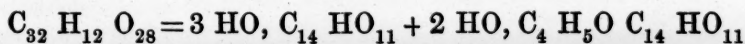


It was shewn that ethylomeconic acid undergoes a curious decomposition in contact with ammonia. It appears very complex; and Mr How gave, as representing the composition of the products he obtained, an ammonia salt of an amide acid, and the acid itself, the following formulæ,



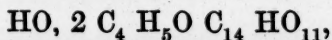
The acid appears to be formed by the grouping together of six atoms of normal amidomeconic acid and one of ammonia.

The second product of the action of hydrochloric acid gas upon meconic acid in alcohol was shewn to be an uncrystalline body, to which the formula, $\text{C}_{32}\text{H}_{12}\text{O}_{28}$, was assigned; and it was considered as formed from the coupling together of equivalents of meconic and ethylomeconic acids,



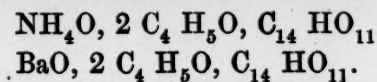
Want of substance prevented a complete study of this body; but it seems, from a few reactions tried, to be certainly more than a mere mixture of the two acids.

The third ether described was obtained from the mother liquors of the preceding two. The formula of this substance, biethylomeconic acid, is



it being meconic acid in which two atoms of basic water are replaced by two equivalents of ether. It is a crystalline substance, fusible in boiling water, in which it also dissolves on agitation. In the dry state it fuses at about 230° Fahr.

It is an acid, monobasic; an analysis was given of its ammonia and its baryta salt, their respective formulæ are



Biethylomeconic acid is not decomposed by ammonia in the cold; but Mr How believes it undergoes a change when heated with this

alkali ; want of material, however, prevented him arriving at a satisfactory conclusion on this point.

3. On the Place of the Poles of the Atmosphere.

By Professor C. Piazzzi Smyth.

This was merely a note on some of the recent discoveries and generalizations, by Lieut. Maury, U.S.N., on the motions of the atmosphere. It had been clearly proved by the extensive researches of Lieut. M., that the trade-winds when rising at the equator, do not, as previously held, return to their own poles, but cross over to the opposite ones ; and thus traverse the extent of the whole earth from pole to pole, in a curvilinear direction, on account of the effect of the rotation of the earth. The whole atmosphere thus partakes of a general movement, the upper half moving towards the poles, and the lower towards the equator, or *vice versa*, according to the latitude of the place ; the former occurring between the parallels of 0° and 30° , and the latter between 30° and 90° . At 0° and 30° two nodes, so to speak, of the upper and lower currents take place ; at the former ascending, and indicated by a low barometer ; at the latter descending, and marked by increased barometric pressure. At the point of 90° , the pole, or thereabouts, the revolution of the currents and their change of direction for N. and S., and *vice versa*, with another node, takes place, and marked, Lieut. Maury *thought*, by a *calm* region, as the two nodal zones of 0° and 30° most undoubtedly are.

As to the place of this calm polar point, which we shall probably long want observations to determine, Lieut. Maury did not place it over the poles of rotation of the world, but over the magnetical poles, without, however, as the present author thought, sufficient reason. Indeed, he much lamented that after the admirable developments made by Lieut. Maury of the motions of the atmosphere, he should have thus brought in merely the *name* of magnetism to clear up one obscure point. Meteorology pursued on the system of strict mechanical and scientific inquiry was now disclosing a most interesting and understandable series of phenomena, and promised a legitimate harvest of more. But the history of this science in times past, points to so many occasions when rational trains of observation were impeded by the gratuitous introduction of a magnetic or electric element, and thought to be needless thereafter, that the author supposed that it might be of some service to shew that there was no probability in

the present case, either from actual observation or natural considerations, that such a force should be looked to for explanation.

1st, Of actual observation. The poles of any force should bear a certain known relation to the equator thereof; and if we find the magnetic equator coincident with that of the atmosphere, which may be considered as marked out by the line of equatorial calms, we might reasonably suppose a connection between their poles. But we do not. The mean positions of these equators are very different from each other, and are subject to such totally different movements through the year, that we cannot legitimately expect any nearer coincidence in their polar points.

2d, Of natural considerations. Mechanical force may always be taken as the cause, and not as the consequence, of the magnetic or electric currents by which it is accompanied. Certainly in the case of an electrical machine, the electric spark may be made to produce mechanical energy, as shewn in knocking small light pith balls about; but how incomparably less is this force to that employed to turn the machine round in the first instance to produce the electricity.

Now, the atmosphere enveloping and rubbing over the world, may be taken as a large electrical machine, and does produce electric and magnetic forces; but these, although startling enough when witnessed by us, little pigmies of men, are of infinitely small moment compared to the force required to keep the whole atmosphere in motion, and to overcome its friction and inertia.

Again, with regard to the intensity of terrestrial magnetism, it is found with one of Gauss's large bars for determining the horizontal force, by being suspended by two wires separated in the direction of its axis, that the whole magnetic force amounts to less than 100,000th part of the weight of the bar, that is, the force or attraction of gravity.

Similar experiments might be adduced, to shew that when a body is heated, though electrical currents may be produced, and may have a certain mechanical power, that yet the quantity of this is almost infinitely small compared to what might be produced by employing the heat directly.

Hence, there can be no reasonable doubt, that the principal movements of the atmosphere must be owing to mechanical and thermotic causes, and only the smaller features to electric and magnetic currents.

A parallel case of the proneness of men to run for an explanation

to magnetism, occurred in the early history of the development of the *law of storms*, and has not yet, so far as I am aware, been distinctly refuted by the public, or withdrawn by its promulgator.

In Colonel Reid's first work (1838) on the revolving motion of the hurricanes, after having, in the earlier portion, detailed, in the most satisfactory manner, the *laws of the phenomena*, he gives, in the latter portion, a glimpse of a *theory* of them, or at least, details an experiment in which, on the surface of a magnetised iron shell representing the earth, a rotation in opposite directions was produced in helices in either hemisphere of the ball. This was thought *very interesting*, as the hurricanes are found to revolve in opposite directions in either half of the world; and it was further stated that in St Helena, where the magnetic intensity is small, hurricanes are unknown; while in the West Indies, where hurricanes are so rife, the magnetic intensity is at a maximum.

Here, it will be observed, is no attempt to shew whether the magnetic power is *sufficient* to cause the observed effect, or has any power in that way at all, nor even to trace whether this particular coincidence at two points, in the tropical belt of the earth, prevailed at all others also; and in the Colonel's last publication (1848) the question and the experiment are withdrawn altogether.

When, however, we examine the subject more extensively, we find a pretty general rule to prevail all round the world, viz., that hurricanes are most frequent in the western parts of those seas where the trade-wind is suddenly stopped by the occurrence of land, and is unknown in the eastern parts of the seas where it begins. Thus, not only is the placid climate of St Helena fully accounted for by being in the eastern position of the South Atlantic, but equally the similar freedom from revolving storms of the Cape De Verde Islands, the NW. and SW. coast of Africa, with California and Peru on the eastern shores of the Pacific.

And again, while the West Indies are pointed out as *likely* places for hurricanes, so are Rio Janeiro, Canton, the Mauritius, and Madras, and, in fact, almost every place where hurricanes have been met with.

The stoppage, then, and interference of the trade-wind, a purely mechanical question, is the cause of the hurricanes, and, according to the greater or less force of the trade-wind, and the greater quantity of air struggling to get over the barrier, as observed in the case of water when a river is in a flood, or on a sea-coast at spring-tide,

so are more numerous and more violent eddies found, and they revolve in different directions in either hemisphere, because the direction of the parent trade-wind is also different in each.*

These mechanical causes, we may be certain, are acting, and must have the chief share in the effects which we observe, and should therefore be followed out in all their consequences, before we attempt to introduce any problematical forces which cannot possibly have much, if they have indeed any effect.

The following Donations to the Library were announced :—

Flora Batava. Aflevering 166. 4to.—*From the King of the Netherlands.*

Mémoires de l'Académie Impériale des Sciences de St Pétersbourg. Sciences Mathématiques, Physiques et Naturelles. Tome IV^{me}, Liv. 3 & 4. 4to.

Mémoires présentés à l'Académie Impériale des Sciences de St Pétersbourg, par divers Savants, et lus dans ses Assemblées. Tome VI^{me}. Liv. 5 & 6. 4to.—*From the Academy.*

Memorie della Reale Accademia della Scienze di Torino. Serie Seconda. Tomo XI. 4to.—*From the Academy.*

Annales de l'Observatoire Physique Central de Russie. 1848. 3 tom. 4to.—*From the Observatory.*

Compte Rendu Annuel, Addressé à M. le Comte Wrontchenko, Ministre des Finances, par le Directeur de l'Observatoire Physique Central de Russie, A. T. Kupffer. 1850. 4to.—*From the Editor.*

The American Journal of Science and Arts. Vol. XII., No. 36. 8vo.—*From the Editors.*

Bulletin de la Société de Géographie. 4^{me} Serie. Tom. I. 8vo.—*From the Society.*

* I have just met with an, at first sight, anomalous instance, in the account of a circular storm experienced by the American exploring expedition under Captain Wilkes in the neighbourhood of the Cape De Verd Islands, a similar latitude to the West Indies, but on the "wrong" side of the Atlantic, and moreover revolving *with* the hands of a watch, "wrong" also. But the *parent* wind in this case is described to have been *SE.*, which explains everything; and shews that the whole phenomenon is an affair of mechanical conditions in the currents of air at the place; that these being reversed, the hurricane phenomena are reversed also, and that there is no magnetic or other virtue residing in either hemisphere, and compelling air to circulate in any particular direction by reason of its *place*.

Abhandlungen der Königl. Akademie der Wissenschaften zu Berlin. 1849. 4to.

Monatsbericht der Königl. Akademie der Wissenschaften zu Berlin. 1850, Jan. — Dec. ; 1851, Jan. — Juni. 8vo.—*From the Academy.*

Proceedings of the Philosophical Society of Glasgow. 1850. Vol. III., No. 3. 8vo.—*From the Society.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1850, Nos. 3 & 4 ; 1851, No. 1. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. 1851. No. 5. 8vo.—*From the Society.*

Monday, 19th January 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read :—

1. Defence of the Doctrine of Vital Affinity, against the objections stated to it by Humboldt and Dr Daubeny. By Dr Alison.

The object of this paper was to fix attention on the great physiological discovery which has been gradually effected during the present century, of the mode in which certain of the elements contained in the earth's atmosphere, under the influence of light and of a certain temperature, are continually employed in maintaining that great vital circulation, of which vegetable structures, animal structures, the air, and the soil, are the successive links ; and to point out that the most essential and fundamental of the changes here effected,—particularly the formation of the different organic compounds in the cells of vegetables,—are strictly *chemical changes*, at least as clearly distinct from any chemical actions yet known to take place in inorganic matters, as the vital contractions of muscles are distinct from any merely mechanical causes of motion ; and justifying the statement of Dr Daubeny, that there appears to be “ a power, residing in living matters ” and producing chemical effects,—in fact manifesting itself most unequivocally by the chemical changes which result from it,—“ distinct, at least in its effects, from ordinary chemical and physical forces.”

But after having made this statement, Dr Daubeny, according to the author of this paper, has thrown a degree of mystery over the subject which is quite unnecessary and even unphilosophical, by refusing to admit—and quoting Humboldt, who has changed his opinion on the subject, and now likewise declines to admit—that these changes are to be regarded as *vital*; both authors (as well as several other recent English authors) maintaining, that as we do not know all the conditions under which ordinary chemical affinities act in living bodies, we are not entitled to assert that these affinities may not yet be found adequate to the production of all the chemical changes which living bodies present; and that until this *negative proposition* is proved, it is unphilosophical and delusive to suppose the existence of any such power, as that to which the term Vital Affinity has been applied, by the author of this paper and several other physiologists.

In answer to this, it is here stated, that as we cannot, strictly speaking, *define* Life or Vitality, we follow the strict rules of philosophy, in *describing* what we call living bodies, whether vegetable or animal, and then applying the term Vital or living, as the general expression for everything which is observed to take place only in them, and which is inexplicable by the physical laws, deduced from the observation of the other phenomena of nature; that according to this,—the only definition of which the term *vital* admits, or by which the objects of Physiology can be defined,—Dr Daubeny has already admitted, in the expressions above quoted from him, that chemical as well as mechanical changes in living bodies, fall under the denomination *vital*; and as the rule of sound logic is “*affirmantibus incumbit probatio*,”—and as it is just as probable *a priori*, that, with a view to the great objects of the introduction of living beings upon earth, the laws of chemistry, as those of mechanics, should be modified or suspended by Almighty Power,—this author maintains that we are as fully justified in referring all great essential chemical phenomena, which are peculiar to living bodies, to peculiar affinities, which we term *vital*, as Haller was to ascribe the peculiar mechanical movements of living bodies, to the vital property of Irritability; and to throw on the mechanical physiologists of his day the burden of proving, if they could, that the laws of motion, perceived in dead matter, were adequate to explain them.

In illustration of the importance, both in Physiology and Pathology, of this principle being held to be established, Dr Alison ad-

duced two examples, *first*, the utter failure of the very ingenious theory of Dr Murray to explain, on ordinary chemical principles, the simplest and most essential phenomena of healthy Secretion; and, *secondly*, the now generally admitted inadequacy of any theory of Inflammation, which does not regard a modification of the *affinities* peculiar to life, and here termed vital, as the primary and essential change, in the matter concerned in that process.

2. On the Fatty Acid of the *Cocculus Indicus*. By Mr William Crowder. Communicated by Dr Anderson.

The following Gentlemen were duly elected as Ordinary Fellows :—

1. EYRE B. POWELL, Esq., Madras.
2. THOMAS MILLER, Esq., Rector, Perth Academy.
3. ALLEN DALZELL, Esq.

Monday, 2d February 1852.

SIR DAVID BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read :—

1. On the Function of the Spleen and other Lymphatic Glands, as originators of the Corpuscular Constituents of the Blood. By Dr Bennett.

The author had been enabled to study the blood corpuscles under circumstances capable of extending our information with regard to their relations, mode of formation, and ultimate destination. In 1845, he had discovered a peculiar condition in human blood, in which the colourless cells were greatly increased in number. This condition he had called leucocythemia, which was always associated with enlargement of the spleen or other lymphatic glands, a circumstance which had induced him to form the opinion that the corpuscles of the blood originated in these organs. This view he sought to establish by discussing at considerable length the following questions, viz. :—*1st*, What relation do the colourless and coloured corpuscles bear to each other? *2d*, Where do they originate? *3d*, What is their ultimate destination?

From the whole inquiry, which included numerous observations on

the blood of vertebral animals, careful investigations into the structure of the ductless glands, and several experiments, he deduced the following conclusions :—

1. That the blood corpuscles of vertebrate animals are originally formed in the lymphatic glandular system, and that the great majority of them on joining the circulation, become coloured in a manner that is as yet unexplained. Hence, the blood may be considered as a secretion from the lymphatic glands, although in the higher animals that secretion only becomes fully formed after it has received colour by exposure to oxygen in the lungs.

2. That in the mammalia, the lymphatic glandular system is composed of the spleen, thymus, thyroid, supra-renal, pituitary, pineal, and lymphatic glands.

3. That in fishes, reptiles, and birds, the coloured blood corpuscles are nucleated cells originating in these glands, but that in mammals, they are free nuclei, sometimes derived as such from the glands, at others, developed within colourless cells.

4. That in certain hypertrophies of the lymphatic glands, their cell elements are proportionally increased in number, and under such circumstances the colourless cells of the blood are also proportionally increased. This is Leucocythemia.

5. That the solution of the corpuscles of the blood, conjoined with the effete matter derived from the tissues, which is not converted into albumen, constitute blood fibrin.

2. On the Mechanical action of Radiant Heat or Light :
On the Power of Animated Creatures over Matter :
On the Sources available to Man for the production
of Mechanical Effect. By Professor William
Thomson.

On the Mechanical Action of Radiant Heat or Light.

It is assumed in this communication that the undulatory theory of radiant heat and light, according to which light is merely radiant heat, of which the vibrations are performed in periods between certain limits of duration, is true. "The chemical rays," beyond the violet end of the spectrum, consist of undulations of which the full vibrations are executed in periods shorter than those of the extreme visible violet light, or than about the eight hundred million millionth

of a second. The periods of the vibrations of visible light lie between this limit and another, about double as great, corresponding to the extreme visible red light. The vibrations of the obscure radiant heat beyond the red end are executed in longer periods than this; the longest which has yet been experimentally tested being about the eighty million millionth of a second.

The elevation of temperature produced in a body by the incidence of radiant heat upon it is a mechanical effect of the dynamical kind, since the communication of heat to a body is merely the excitation or the augmentation of certain motions among its particles. According to Pouillet's estimate of heat radiated from the sun in any time, and Joule's mechanical equivalent of a thermal unit, it appears that the mechanical value of the solar heat incident perpendicularly on a square foot above the earth's atmosphere is about eighty-four foot-pounds per second.

Mechanical effect of the statical kind might be produced from the solar radiant heat, by using it as the source of heat in a thermodynamic engine. It is estimated that about 556 foot-pounds per second of ordinary mechanical effect, or about the work of "one horse power," might possibly be produced by such an engine exposing 1800 square feet to receive solar heat, during a warm summer day in this country; but the dimensions of the moveable parts of the engine would necessarily be so great as to occasion practical difficulties in the way of using it with economical advantage that might be insurmountable.

The *chemical* effects of light belong to the class of mechanical effects of the statical kind; and reasoning analogous to that introduced and experimentally verified in the case of electrolysis by Joule, leads to the conclusion that when such effects are produced there will be a loss of heating effect in the radiant heat or light which is absorbed by the body acted on, to an extent thermally equivalent to the mechanical value of the work done against forces of chemical affinity.

The deoxidation of carbon and hydrogen from carbonic acid and water, effected by the action of solar light on the green parts of plants, is (as the author recently found was pointed out by Helmholtz* in 1847), a mechanical effect of radiant heat. In virtue of this action

* "Ueber die Erhaltung der Kraft, von Dr H. Helmholtz." Berlin, 1847.

combustible substances are produced by plants; and its mechanical value is to be estimated by determining the heat evolved by burning them, and multiplying by the mechanical equivalent of the thermal unit. Taking, from Liebig's *Agricultural Chemistry*, the estimate 2600 pounds of dry fir wood for the annual produce of one Hessian acre, or 26,910 square feet, of forest land, (which in mechanical value appears not to differ much from estimates given in the same treatise for produce of various kinds obtained from *cultivated* land,) and assuming, as a very rough estimate, 4000 thermal units centigrade as the heat of combustion of unity of mass of dry fir wood; the author finds 550,000 foot-pounds (or the work of a horse-power, for 1000 seconds), as the mechanical value of the mean annual produce of a square foot of the land. Taking $50^{\circ} 34'$ (that of Giessen,) as the latitude of the locality, the author estimates the mechanical value of the solar heat which, were none of it absorbed by the atmosphere, would fall annually on each square foot of the land, at 530,000,000 foot-pounds; and infers that probably a good deal more, $\frac{1}{1000}$ of the solar heat, which actually falls on growing plants, is converted into mechanical effect.

When the vibrations of light thus act during the growth of plants, to separate, against forces of chemical affinity, combustible materials from oxygen, they must lose *vis viva* to an extent equivalent to the statical mechanical effect thus produced; and therefore quantities of solar heat are actually put out of existence by the growth of plants, but an equivalent of statical mechanical effect is stored up in the organic products, and may be reproduced as heat, by burning them. All the heat of fires, obtained by burning wood grown from year to year, is in fact solar heat reproduced.

The actual convertibility of radiant heat into statical mechanical effect, by inanimate material agency, is considered in this paper as subject to Carnot's principle; and a possible connection of this principle with the circumstances regarding the quality of the radiant heat (or the colour of the light), required to produce the growth of plants, is suggested.

On the Power of Animated Creatures over Matter.

The question, "Can animated creatures set matter in motion in virtue of an inherent power of producing mechanical effect?" must be answered in the negative, according to the well-established theory

of animal heat and motion, which ascribes them to the chemical action (principally *oxidation*, or a combustion at low temperatures), experienced by the food. A principal object of the present communication is to point out the relation of this theory to the dynamical theory of heat. It is remarked, in the first place, that both animal heat and weights raised or resistance overcome, are *mechanical* effects of the chemical forces which act during the combination of food with oxygen. The former is a dynamical mechanical effect, being thermal motions excited; the latter is a mechanical effect of the statical kind. The whole mechanical value of these effects, which are produced by means of the animal mechanism in any time, must be equal to the mechanical value of the work done by the chemical forces. Hence, when an animal is going up-hill or working against resisting force, there is less heat generated than the amount due to the oxidation of the food, by the thermal equivalent of the mechanical effect produced. From an estimate made by Mr Joule, it appears that from $\frac{1}{4}$ to $\frac{1}{6}$ of the mechanical equivalent of the complete oxidation of all the food consumed by a horse may be produced, from day to day, as weights raised. The oxidation of the whole food consumed being, in reality, far from complete, it follows that a less proportion than $\frac{5}{6}$, perhaps even less than $\frac{3}{4}$, of the heat due to the whole chemical action that actually goes on in the body of the animal, is given out as heat. An estimate, according to the same principle, upon very imperfect data, however, is made by the author, regarding the relation between the thermal and the nonthermal mechanical effects produced by a man at work; by which it appears that probably as much as $\frac{1}{6}$ of the whole work of the chemical forces arising from the oxidation of his food during the 24 hours, may be directed to raising his own weight, by a man walking up-hill for 8 hours a-day; and perhaps even as much as $\frac{1}{4}$ of the work of the chemical forces, may be directed to the overcoming of external resistances by a man exerting himself for 6 hours a-day in such operations as pumping. In the former case there would be not more than $\frac{5}{6}$, and in the latter not more than $\frac{3}{4}$ of the thermal equivalent of the chemical action emitted as animal heat, on the whole, during the 24 hours, and the quantities of heat emitted during the times of working would bear much smaller proportions respectively than these, to the thermal equivalents of the chemical forces actually operating during those times.

A curious inference is pointed out, that an animal would be sensibly less warm in going up-hill than in going down-hill, were the breathing not greater in the former case than in the latter.

The application of Carnot's principle, and of Joule's discoveries regarding the heat of electrolysis and the calorific effects of magneto-electricity, is pointed out; according to which it appears nearly certain that, when an animal works against resisting force, there is not a *conversion of heat into external mechanical effect*, but the full thermal equivalent of the chemical forces is *never produced*; in other words that the animal body does not act as a *thermo-dynamic engine*; and very probable that the chemical forces produce the external mechanical effects through electrical means.

Certainty regarding the means in the animal body by which external mechanical effects are produced from chemical forces acting internally, cannot be arrived at without more experiment and observation than has yet been applied; but the relation of mechanical equivalence, between the work done by the chemical forces, and the final mechanical effects produced, whether solely heat, or partly heat and partly resistance overcome, may be asserted with confidence. Whatever be the nature of these means, consciousness teaches every individual that they are, to some extent, subject to the direction of his will. It appears, therefore, that animated creatures have the power of immediately applying, to certain moving particles of matter within their bodies, forces by which the motions of these particles are directed to produce desired mechanical effects.

*On the Sources available to Man for the Production of
Mechanical Effect.*

Men can obtain mechanical effect for their own purposes either by working mechanically themselves, and directing other animals to work for them, or by using natural heat, the gravitation of descending solid masses, the natural motions of water and air, and the heat, or galvanic currents, or other mechanical effects produced by chemical combination, but in no other way at present known. Hence the stores from which mechanical effect may be drawn by man belong to one or other of the following classes:—

- I. The food of animals.
- II. Natural heat.

III. Solid matter found in elevated positions.

IV. The natural motions of water and air.

V. Natural combustibles (as wood, coal, coal-gas, oils, marsh gas, diamond, native sulphur, native metals, meteoric iron.)

VI. Artificial combustibles (as smelted or electrolytically-deposited metals, hydrogen, phosphorus.)

In the present communication, known facts in natural history and physical science, with reference to the sources from which these stores have derived their mechanical energies, are adduced to establish the following general conclusions :—

1. *Heat radiated from the sun* (sunlight being included in this term) *is the principal source of mechanical effect available to man.** From it is derived the whole mechanical effect obtained by means of animals working, water-wheels worked by rivers, steam-engines, and galvanic engines, and part at least of the mechanical effect obtained by means of windmills and the sails of ships not driven by the trade-winds.

2. The motions of the earth, moon, and sun, and their mutual attractions, constitute an important source of available mechanical effect. From them all, but chiefly, no doubt, from the earth's motion of rotation, is derived the mechanical effect of water-wheels driven by the tides. The mechanical effect so largely used in the sailing of ships by the trade-winds is derived partly, perhaps principally, from the earth's motion of rotation, and partly from solar heat.

3. The other known sources of mechanical effect available to man are either terrestrial—that is, belonging to the earth, and available without the influence of any external body,—or meteoric,—that is, belonging to bodies deposited on the earth from external space. Terrestrial sources, including mountain quarries and mines, the heat of hot springs, and the combustion of native sulphur, perhaps also the combustion of all inorganic native combustibles, are actually used, but the mechanical effect obtained from them is very inconsiderable, compared with that which is obtained from sources belonging to the two classes mentioned above. Meteoric sources, including only the heat of newly-fallen meteoric bodies, and the combustion of meteoric iron, need not be reckoned among those available to man for practical purposes.

* A general conclusion equivalent to this was published by Sir John Herschel in 1833.—See his *Astronomy*, edit. 1849, § (399.)

The following Gentleman was duly elected an Ordinary Fellow :—

Dr JOHN WYLIE, late Physician-General, Madras.

The following Donations to the Library were announced :—

- Smithsonian Contributions to Knowledge. Vol. II. Collection of Various Reports. 4to.—*From the Smithsonian Society.*
 Transactions of the Zoological Society of London. Vol. IV., Pt. 1. 4to.
 Proceedings of the Zoological Society of London. Nos. 201–213. 8vo.
 Proceedings of the American Association for the Advancement of Science. August 1850. 8vo.—*From the Association.*
 Transactions of the Horticultural Society of London. 2d Series. Vol. II., Pts. 3, 4, 5, 6; Vol. III., Pts. 1, 2, 3. *From the Society.*
 Novi Commentarii Academiæ Scientiarum Instituti Bononensis. Tom. VI., VII., VIII., IX., X. 4to.—*From the Academy.*
 Memorie della Accademia delle Scienze dell' Istituto di Bologna. Tomo I. 4to.—*From the Academy.*

Monday, 16th February 1852.

MR RUSSEL in the Chair.

The following Communications were read :—

1. On some improvements in the instruments of Nautical Astronomy. By Professor C. Piazzzi Smyth.

The excessive motion of a ship at sea renders the use of the ordinary instruments employed on land impossible, and restricts the sailors to the use of one on the principle of the duplication of images discovered by Hadly.

The favourite form is at present, and has always been, that of a quadrant or sextant, *i.e.*, a part of a circle, rather than a whole one, though this has often been brought forward by scientific men, and proved to be the most accurate : but the construction of these circles was generally too complicated, and practically unsuited to the circumstances usually met with at sea.

Taking the best of the sextants, then, as the form generally found in actual use, the author shewed that it laboured under many disad-

vantages, some peculiarly its own, others shared in common with the circular variety of doubly-reflecting instruments; and that, in a word, they were all, though convenient enough for day observations of the sun and moon, extremely inconvenient for, if not altogether incapable of, observations of the stars at night.

The author then pointed out, in some instruments exhibited, their various imperfections, explaining the cause, and giving the mode of removing them; and finally produced a new description of circle, in which he had had all the above-mentioned imperfections corrected.

The execution of the idea had been entrusted to Mr John Adie, and had been performed so efficiently, that the author considered that his best thanks were due to Mr Adie, who had thus most materially assisted the carrying out of the original ideas.

2. Notice of an Antique Marble Bust (with Photographs). By Andrew Coventry, Esq.

Mr Coventry read a short notice of an antique marble bust which he had had the good fortune to purchase from a gentleman in Westmoreland, last autumn, and had reason to believe had been brought from Italy.

The bust, of which some very fine photographs were exhibited (executed by Mr Tunny of Newington, and Captain Scott, R.N.), Mr Coventry considered to be a portrait, and a work of high Greek art. On various grounds, but chiefly from its great resemblance to the busts of the young Augustus:—from the hair being treated in the method in use in his day and soon after abandoned; and from the accordance of the features with the known history and character of Octavia, the sister of Augustus, Mr Coventry was disposed at first to think it the bust of that celebrated personage. But he deferred to an opinion which he had received by that day's post from Mr Burgon of the British Museum, that it was the bust of Antonia Augusta, Octavia's second daughter by Marc Antony, in honour of whom coins had been struck by her son Claudius. Mr Burgon's opinion rested on the authority of those coins, which were inscribed with her name and bore the strongest resemblance to the photographs Mr Coventry had forwarded to him from his bust.

3. Note on a Method of procuring very rapid Photographs (with Specimens). By John Stuart, Esq.

The following method of taking collodion portraits and views, is so easy in manipulation, and so rapid in its results, that it is worthy of the notice of every lover of photography. By means of an apparatus adjusted to the lens of the camera, so as to open and close it instantaneously, views can be taken with sufficient rapidity to delineate vehicles in motion, assemblies of people, and even the waves of the sea.

It also produces a picture combining both the positive and negative on the same plate; the positive being shewn by a reflected, and the negative by a transmitted light. Copies on paper can be thrown off from these plates to any extent; but this is a difficult operation, as any daylight, unless *very carefully* subdued, proves too strong. The process is as follows:—A plate of glass perfectly clean on the surface, and free from moisture, is coated with collodion, made as under. It is then plunged into a bath of nitrate of silver in solution (distilled water), 45 grs. to the oz. for sunlight, (100 grs. to the oz. for portraits to be taken *instantaneously in a room*), and allowed to remain till an oily appearance on the plate disappears. The plate is then fit for the camera, and will remain sensitive for twelve hours, or probably longer. After the view is taken, develop the picture with a solution of the sulphate of iron (20 grs. to the oz.) slightly heated, and fix it (after washing) with a saturated solution of hyposulphate of soda. The plate when dry, must be kept some days, and then varnished with a very thin solution of Canada varnish in spirits of turpentine. Previous to varnishing, the picture should be brushed over with a camel-hair brush, which adds much to its beauty and clearness. In a very *dull light* (but out of doors), the above proportion, 45 grs. nitrate silver, will take portraits and views, under ten seconds most distinctly, and unless the opening and shutting of the camera be very quick, better pictures can be produced thus than those taken *instantaneously in strong sunlight*. The collodion found best to suit this process is made as under.—By weight sixty parts of pounded nitre, forty of rectified sulphuric acid, and two of sea island cotton. The cotton must remain three minutes in the mixture, and then be dried and dissolved in ether along with as much

of the precipitate of nitrate of silver by iodide of potassium as it will absorb. The collodian should be very thin and as transparent as water.

The following Gentleman was duly elected an Ordinary Fellow.

JAMES CUNNINGHAM, Esq., W.S.

The following Donations to the Library were announced :—

Verhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. 4to.—*From the Academy.*

Journal of the Horticultural Society of London. Vol. VII., Part 1. 8vo.—*From the Society.*

Museum of Practical Geology :—On the Science of Geology and its applications. By Andrew C. Ramsay ;—On the value of extended knowledge of Mineralogy and the Process of Mining. By W. W. Smyth ;—On the Importance of Special Scientific Knowledge. By John Percy, M.D. 8vo.—*From the Museum.*

Monday, 1st March 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in the Chair.

The following Communications were read :—

1. On some Salts and products of Decomposition of Pyromeconic Acid. By Mr James F. Brown. Communicated by Dr Anderson.

The pyromeconic acid employed in the following experiments was obtained by distilling impure meconic acid at a temperature of about 500° or 600° Fahr., when there is obtained a highly crystalline sublimate of a dark colour and empyreumatic odour. Its purification was effected by pressing the crystals so procured between folds of filtering paper, and finally subliming them at a moderate heat in cylindrical glass vessels provided with paper diaphragms. As thus

obtained, it is in the form of beautiful large transparent plates, of ready solubility in water and alcohol. It is also soluble in ether, reddens litmus faintly, and is completely volatile at 212° , a property which may serve as a test of its purity from paracomenic acid, that acid requiring a much higher temperature for its sublimation. Several attempts were made to prepare the ammonia and potash salts of this acid, but without success.

The acid gave on analysis per-centage results agreeing with the formula $C_{10} H_3 O_5 + H O$, which is that hitherto adopted.

Pyromeconate of baryta, $Ba O, C_{10} H_3 O_5 + H O$, precipitates as small colourless silky needles, when a warm ammoniacal solution of pyromeconic acid is mixed with acetate of baryta. By evaporation *in vacuo*, it crystallises in four-sided prisms of a yellow colour. It is the most soluble in water of all the earthy salts of this acid, 100 parts of water at 60° dissolving 2.50 parts of the salt.

Pyromeconate of strontia, $Sr O, C_{10} H_3 O_5 + H O$. This salt may be obtained by mixing alcoholic solutions of the acid with ammonia and nitrate of strontia, when there ensues an immediate precipitate of the salt in small colourless crystals, of sparing solubility in water and alcohol, 100 parts of the former at 68° dissolving 1.3 parts.

Pyromeconate of lime, $Ca O C_{10} H_3 O_5 + H O$. This salt was prepared in a manner similar to that of the two preceding. It is soluble in water and alcohol to a small extent, 100 parts of the former at 68° , dissolving 0.31 of the salt.

Pyromeconate of magnesia, $Mg O C_{10} H_3 O_5$, falls as an amorphous powder, when acetate of magnesia is added to an ammoniacal solution of pyromeconic acid.

The pyromeconates of lead, copper, and iron, have already been examined, and I merely repeated their analysis, to confirm the formulæ which have been given for them.

The products of decomposition of this acid were next examined, cold nitric acid of sp. gr. 1.4 decomposes it with the evolution of nitrous acid gas, and production of oxalic and hydrocyanic acids. Sulphuric in the cold has no action on pyromeconic acid, but when gently warmed, it dissolves to a colourless fluid, which, upon cooling, deposits the acid again. I failed, however, in procuring an ether or a chlorine substitution product of this acid.

Bromopyromeconic acid, $C_{10} H_2 Br O_5 + H O$, is obtained in the form of beautiful small colourless prisms, when bromine water

is made to react on excess of pyromeconic acid. These crystals are slightly soluble in water, but readily so in boiling alcohol, they redden litmus faintly, and impart to persalts of iron a deep purple colour, quite distinct from the red produced by the original acid. Nitrate of silver causes no precipitate in solutions of this acid; neither when boiled does it reduce the oxide to the metallic state. Submitted to destructive distillation it fuses, and then blackens; hydrobromic acid is evolved in large quantity; and after some time a white crystalline sublimate* makes its appearance, but in quantity too small to admit of examination.

Bromopyromeconate of lead, $\text{Pb O C}_{10} \text{H}_2 \text{Br. O}_5 + \text{H O}$, is precipitated as small dense crystalline grains, when warm alcoholic solutions of the acid and acetate of lead are mixed together.

2. On the Organs in which Lead accumulates in the Horse, in cases of slow poisoning by that Metal. By Dr George Wilson.

* The chief object of this paper was to state the result of a careful analysis of the viscera of a mare, which had died after receiving daily, for six weeks or more, carbonate of lead in its food and drink. Portions of the lungs, the heart, the large intestine and its contents, the stomach and duodenum, the spleen, the kidney, and the liver, were subjected to analysis by the author, assisted by Mr Stevenson Macadam.

As the quantity of animal matter was large, it became a question what preliminary process should be followed, with a view to facilitate the final charring to which each organ must be subjected. Sulphuric acid was rejected on account of its liability to contain lead, and the certainty of its forming an insoluble compound with the lead it might encounter in the tissues. Nitric acid had been found in previous trials to act too slowly; and a mixture of chlorate of potass and hydrochloric acid left too large a residue of saline matter, to seem applicable. Aqua regia, accordingly, which has been recommended in such cases by the French chemists, was tried, and was found to answer every expectation.

Each of the organs was digested in a mixture of one part of nitric acid and two of hydrochloric acid, which dissolved everything but the fat. The resulting solution was evaporated to dryness, the resi-

due charred, digested in nitric acid, and the acid solution filtered and exposed to a stream of sulphuretted hydrogen. A dark precipitate was obtained which was dissolved in dilute nitric acid, evaporated to dryness and redissolved in water, acidulated with hydrochloric acid. This solution was tested with sulphuretted hydrogen, sulphuric acid, iodide of potassium, and bichromate of potass, and acted characteristically with all the tests. The spleen yielded the fullest indications of the presence of lead, the liver came next in shewing indications of the metal, then the lungs, afterwards the kidneys, and lowest of all, the intestinal canal.

It would thus appear, that, in the case under notice, the spleen and not the liver was the organ in which lead occurred most abundantly. The author, accordingly, suggests that the spleen rather than the liver should be the organ subjected to analysis in cases of suspected slow poisoning with lead; at least, where a single organ only is analysed.

3. Notice regarding the occurrence of Pumice in the Island of Tyree. By The Duke of Argyll.

The Duke of Argyll (in connection with other evidences of a more conclusive kind, that, during some portion of the tertiary ages, there had been some subaerial volcanic action in the Hebrides) explained the mode in which pumice occurred in the Island of Tyree. The pumice was found to form a bed or layer along the line of an ancient sea-beach, and was in the shape of balls more or less closely packed together. These appearances seemed to indicate that they had come in on the waters of a tide or current in large numbers at a time. They were manifestly sea-borne; and the only question was as to the most probable source. The bay and general line of coast on which they are found is not that which is opposed to the modern current of the Gulf Stream; but, on the contrary, looks eastward, that is to say, towards the trap Islands of Mull, Staffa, &c.

The author considered it improbable that the origin of the pumice could have been very distant, inasmuch as the greater the distance, the greater would be the dispersion of such light floating bodies by winds and currents; and it was difficult to suppose that either from the West Indies or from Iceland, pumice could have concentrated in such quantities on such a spot. Its presence, however, and its deposition, in the manner described, could be easily accounted for, if

any portion of the traps of Mull, Staffa, or the adjacent islets, were poured out by a subaerial volcano; and these the author considered as placed almost beyond dispute, by the facts brought to light in connection with the tertiary leaf-beds, overflowed by lavas, at the opposite headland of Ardtan, in Mull.

4. Recent Observations on the direction of the Striæ on Rocks and Boulders. By James Smith, Esq.

Mr Smith of Jordanhill next read a paper on the direction of the striæ on rocks and boulders in the West of Scotland.

It had generally been supposed that the cause, whatever it was, which lodged the erratic block beds in their present position had proceeded from the north and west.

This was true with respect to the basin of the Clyde and the east coast of Scotland; but on the western coast of Argyllshire, at Loch Crinan and Appin he had observed that the strike side (stoss seite) of the rocks pointed to the east, and the lee side (lee seite) to the west, shewing that, in these cases, the direction of the moving force was from east to west. Mr Hopkins' recent observations on the direction from which boulders near Oban have been derived, shewed that they also must have come in the same direction.

Mr Smith then observed the occurrence of a large angular granite block on the shore at Helensburgh, which apparently must have been transported over ice. He had also observed at the Island of Cumbra an angular mass of trap, resting on a scratched rock, and split vertically into several pieces; he had observed blocks split in the same manner, which had fallen from the terminus of the glacier of Grindelwald.

The following Donations to the Library were announced:—
Philosophical Transactions of the Royal Society of London. 1851.

Part 2. 4to.

List of Fellows of Do. 30th Nov. 1851. 4to.—*From the Society.*

Memoirs of the Royal Astronomical Society. Vol. XX. 4to.

Notices of Do. Vol. II. 1850-1. Nos. 1-9. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society. Vol. VIII., Part 1. 8vo.—*From the Society.*

American Journal of Science and Arts. Vol. XIII., No. 37. 8vo.
—*From the Editors.*

Transactions of the Royal Scottish Society of Arts. Vol. III.,
Part 5. 8vo.—*From the Society.*

Transactions of the Architectural Institute of Scotland. Vol. II.,
Part 2. 8vo.—*From the Institute.*

Journal of Agriculture, and Transactions of the Highland and
Agricultural Society of Scotland. N.S. No. 36. 8vo.—
From the Society.

Astronomical and Magnetical and Meteorological Observations made
at the Royal Observatory, Greenwich, in the year 1850. 4to.
—*From the Royal Society.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften.
Mathemat. Natur. Classe. Bd. VII., Stück 1 & 2. 8vo.—
From the Academy.

Flora Batava. No. 167. 4to.—*From the King of Holland.*

Guide to Northern Archæology, by the Royal Society of Northern
Antiquaries of Copenhagen. Edited by the Right Hon. the
Earl of Ellesmere. 8vo.—*From the Editor.*

Papers on Railway and Electric Communications, &c., &c. By
Walter White. 12mo.—*From the Author.*

Rules and Regulations, and List of Members, of the Athenæum.
12mo.—*From the Athenæum.*

Monday, 15th March 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in
the Chair.

The following Communications were read :—

1. On the Analysis of some Scottish Minerals.
By Dr A. J. Scott, H.E.I.C.S.

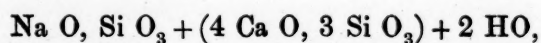
In this paper, the author detailed the analysis of some minerals
which were placed at his disposal through the kindness of Dr Ander-
son, in whose laboratory they were examined by him.

Pectolite.—The first of the series was a mineral found at Storr,
in the Island of Skye. It bears a great resemblance to dysclasite

in its external characters, but differs in appearance from that mineral, in possessing a much higher lustre. Its quantitative analysis gave the following results.

Silicic acid,	.	.	52.007
Alumina,	.	.	1.820
Lime,	.	.	32.854
Magnesia,	.	.	6.396
Soda,	.	.	7.670
Water,	.	.	5.058
			<hr/>
			99.805

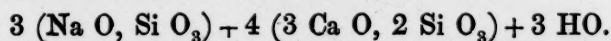
agreeing with the formula,



the calculation being,

Silicic acid, 4 atoms,	181.2	—	52.6
Lime, 4 ...	112.0	—	32.4
Soda, 1 ...	31.3	—	9.1
Water, 2 ...	18.		
		<hr/>	<hr/>
		342.5	100

which approximates much more closely to the experimental results, than the complicated formula proposed by Berzelius,

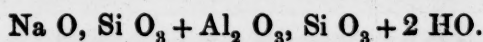


The occurrence of this mineral in Scotland has not been hitherto noticed.

Natrolite.—A specimen received from Mr Rose of this city, and found in a railway tunnel at Bishopstoun in Renfrewshire, was found to consist of

Silicic acid,	.	.	47.626
Alumina,	.	.	27.170
Soda,	.	.	15.124
Water,	.	.	9.780
			<hr/>
			99.700

Corresponding with the well-known formula of Natrolite,

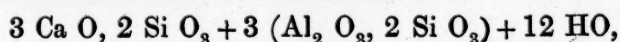


Laumonite.—Found at Storr in Skye, in a vein traversing trap,

and associated with stilbite. It was supposed by some to be hypostilbite, but a quantitative examination gave the following results,

Silicic acid,	.	.	53.048
Alumina,	.	.	22.943
Lime,	.	.	9.676
Water,	.	.	14.639
			<hr/>
			100.306

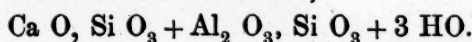
This analysis corresponds to that of Laumonite, but its formula given by Gerhardt is not very satisfactory,



Scolezite.—A mineral found in Mull, consisting of long radiated needles, the composition of which was found to be,

Silicic acid,	.	.	46.214
Alumina,	.	.	27.0
Lime,	.	.	13.450
Water,	.	.	13.780
			<hr/>
			100.444

corresponding to the formula of scolezite,



2. On a necessary Correction in the Height of the Barometer depending on the Force of the Wind. By Captain Henry James, R.E. Communicated by Professor Piazzzi Smyth.

During the frequent violent gales of last autumn, the author had remarked the excessive fluctuation of the barometer; and following up this phenomenon by means of the portable aneroid barometer, he found that not only was this fluctuation dependent on the wind and on the barometer being in a screened position; but that accompanying the fluctuation was a constant depression increasing in amount with the velocity of the air, and that this depression amounted in strong gales to a larger quantity than all the other usual corrections applied to a barometrical reading; and must be applicable to all the ordinary positions where barometers are observed, whether by sea or land.

The reason of this depression was then entered into, and the amount of numerical correction was given, as depending on the velocity of the wind, and the peculiarity of the exposure.

Some observations on the Charr (*Salmo umbla*), relating chiefly to its Generation and Early Stage of Life.
By John Davy, M.D., F.R.S. Lond. & Edin., Inspector-General of Army Hospitals.

The observations contained in this paper are given under several heads: 1st, on the roe and milt of the Charr; 2dly, on the time required for hatching the ova, and on the young fish in progress after exclusion; 3dly, on some agencies and circumstances supposed likely to exert an influence on both.

The principal facts which the author considers as established by his observations are the following:—

1st, That the time required for hatching the ova is variable, ranging from about forty to ninety days, according to the temperature of the water.

2d, That after exclusion the young fish can live at least sixty days without taking food, deriving the material required for its support and growth from itself, and chiefly from the store contained in its yolk.

3d, That under favourable circumstances it attains its perfect form in from about sixty to seventy days, when it becomes dependent for its subsistence chiefly on food which it has to seek or procure from without.

4th, That running water is not essential to the hatching of its ova; and in consequence of its breeding place being distinct from that of the trout, it is exposed to little risk of being lost as a species by repeated crossings with the trout.

5th, That salt water, even of greater saltness than sea water, is not immediately fatal to the embryo; that a partial development of the ovum may take place in brackish water; and that young fish can exist some days in such water, rendering it probable that the adult may be capable of living in a tidal stream, or even in the sea, where it is stated that the Welsh Charr has been caught.

6th, That the young charr can endure confinement for several days in water of small bulk, such as may be used for transporting it from place to place, especially if oxygen gas be supplied in the place of common air.

7th, That the young fish can bear without any immediate apparent injury, a temperature removed only a degree or two from the freezing-

point of water ; and also a higher temperature, ranging from 60° to 70° ; but not above 83° , a temperature which in the single instance tried was almost immediately fatal to it.

In conclusion the author briefly adverts to the application of the results obtained to the breeding and transporting of the fish, adding some remarks on the quality of water essential to its healthy condition and preservation.

Monday, 5th April 1852.

RIGHT REVEREND BISHOP TERROT, Vice-President, in
the Chair.

The following Communications were read :—

1. On a modification of the Process for the determination of Nitrogen in Organic Compounds. By Alexander Kemp, Esq.

Two methods are at present followed by chemists for the analysis of organic bodies containing nitrogen. In the first of these the nitrogen is directly separated from the substance, and measured in a pure state ; while in the second method it is converted into ammonia, collected and weighed, its amount being calculated from the known composition of this latter substance.

In accordance with the first-named mode of proceeding, the substance is burned at a high temperature, in contact with oxide of copper, chromate of lead, or some other body capable of yielding oxygen, when the carbon of the organic substance becomes converted into carbonic acid, and its hydrogen into water, while all the nitrogen is given off in a free state. Two methods may now be adopted for ascertaining its quantity. In that recommended by M. Dumas, the evolved gases are collected in a series of graduated glass tubes, previously filled with mercury, and containing some potash ley in the upper part, which serves to absorb the carbonic acid, leaving the nitrogen, which may then be measured, and its weight calculated from its known volume and density, due allowance being made for the temperature, pressure, and the presence of aqueous vapour.

According to Liebig, the same object may be more easily and rapidly attained, by comparing the volume of the carbonic acid gas produced with that of the nitrogen given out in the operation. This

method, however, is only applicable when the amount of carbon contained in the substance is known, and would not apply to those analysis in which the nitrogen alone required to be determined. Having, as in the previously described operation, collected the mixed gases in graduated tubes, their united volume is read off and noted. After this has been done, caustic potash ley is introduced to absorb the carbonic acid. The residual gas, which is nitrogen, is then measured, and the proportion between the volumes of the two gases is at once ascertained. Now, as each atom of carbon produces one of carbonic acid, occupying the same space as an atom of nitrogen, the proportion between the number of atoms and the volumes of the two gases will be the same; and as the number of atoms of carbon is known, that of the nitrogen can be very easily calculated. The principal advantage of Baron Liebig's method consists in this, that it is not requisite to make corrections for temperature, pressure, or watery vapour contained in the gases, as they are both subjected to the same influences in these respects.

Either of these methods will, in careful and experienced hands, yield very accurate results; but the time required, as well as the necessity of using a somewhat complicated apparatus, renders their application to common analyses almost impracticable.

A much more easily and quickly performed mode of operating was proposed a few years ago by Varrentrapp and Will. These chemists ascertained, by a series of very carefully-conducted experiments, that all organic bodies containing nitrogen, unless in the form of nitric acid, when heated in contact with a mixture of the hydrates of lime and soda, give off that nitrogen in the form of ammonia; and this being collected in a solution of hydrochloric acid, is converted into the double chloride of platinum and ammonium by the addition of bichloride of platinum; and this latter substance being carefully washed, dried, and weighed, gives, by a simple calculation, the amount of nitrogen in the analysed substance.

The method of Varrentrapp and Will, just mentioned, has the great advantage of being much more easily performed than either of the two previously referred to, and at the same time a much less complex form of apparatus may be used in the operation; nevertheless, from the necessity of performing several operations before finally weighing the ammonio-chloride of platinum, several hours must always elapse before the result can be obtained.

An improvement on this process was suggested by M. Peligot, who conveys the evolved ammonia into a quantity of sulphuric acid of known strength, and then ascertains how much of it has been neutralised, by saturating it after the operation with an alkali, a solution of lime and sugar being used for this purpose ; or, as Mr Mitchell since then proposed, caustic soda solution may be substituted for the lime with advantage, as it is not apt to change by being kept, either from spontaneous decomposition, or the absorption of carbonic acid, which indeed would not alter its neutralising power, nor affect the delicacy of the operation, unless it took place to a very great extent. This last-named method has the very great advantage of being quickly performed, so that as many as six or eight analyses can be easily made in the time required for one, according to the method of Varrentrapp and Will. The only difficulty lies in the preparation of the solution of sulphuric acid, which must be done by guess, and the proportion then ascertained by a baryta analysis, which is not a very easy operation, from the finely-divided sulphate of baryta passing readily through the filter.

From these circumstances I was induced to try if the sulphuric acid could not be replaced by some substance easily obtainable, of definite compositions, in the solid form, not hygroscopic, and of which the quantity could be easily determined by weighing, without being liable to those sources of error which apply to sulphuric and most other acids. The substance I have found to fulfil these conditions is the anhydrous bisulphate of potash, a salt described by Jacquelin in the *Annales de Chimie et de Physique* for 1839, but the existence of which seems to be doubted by many chemists. Into this point I shall not at present enter particularly, as I have not yet completed some observations upon this subject with which I have lately been engaged ; but this has been ascertained, that if more than two equivalents of sulphuric acid be added to any salt of potash containing a volatile acid, and the mixture be exposed to heat at a certain temperature, hydrated bisulphate of potash is formed ; and if the temperature be now raised to incipient redness, in the dark, vapours escape, and the anhydrous bisulphate, of perfectly definite composition, remains, which suffers no farther alteration, even when the heat is continued for so long a period as three hours—that is, if it be not carried beyond incipient redness in the dark.

In order to ascertain this latter point, I have had eight specimens

prepared and analysed in several different ways. 1st, 10 grains, precipitated by nitrate of baryta, gave 18·31 grains of sulphate of baryta, theory requires 18·33 grains; while, for the hydrated bisulphate, 17·12 grains would be the quantity. 2d, 12·72 grains in a second experiment gave 23·24 baryta salt, theory 23·32.

2d, 12·72 grains of the salt were carefully introduced into a hard glass tube, and an excess of freshly-ignited oxide of lead added, but so as not to come in contact with the salt, the tube with its contents was then carefully weighed, and heated to redness so as to fuse both substances, but no loss of weight could be detected; the hydrated salt would have lost about 0·8 grains.

3d, 12·72 grains of the salt were dissolved in hot water, and slightly coloured with litmus; to this was added a solution of 5·32 grains of recently-ignited carbonate of soda in a measured quantity of water; the whole of this, being the calculated quantity, was required to restore the blue colour to the hot solution coloured by the litmus.

4th, The whole of the eight specimens were tested as to their neutralising powers by means of the same solution of caustic soda, and found to agree; there can therefore be little doubt that the anhydrous bisulphate of potash can be easily got, and of definite composition.

Having thus endeavoured to shew that the anhydrous bisulphate of potash can be obtained of definite neutralising power, little need be said with regard to its application, as it is intended merely as a substitute for the sulphuric acid used in Peligot's process, and that entirely on account of the ease with which its quantity may be determined by weighing alone, without the necessity of having recourse to any mode of analysis, as is indispensable when any acid solution is made use of. One other advantage may be mentioned—the salt is neither deliquescent nor hygroscopic, for when 10 grains in fine powder were exposed in the laboratory during the night in an open watch-glass, they had not gained ·001 grain by the morning.

In employing the salt in an analysis, any convenient quantity is weighed out and dissolved in warm water in a beaker-glass, and slightly coloured with litmus; a part of this solution is then introduced into the bulb-tube, and made use of in the analysis; afterwards it is returned to the beaker-glass, and neutralised with solution of caustic soda; the difference between the quantity of soda required,

and what would have been required before the combustion, gives us one of the elements for calculating the analysis.

In order to neutralise the acid reaction of one equivalent of the bisulphate, one equivalent of ammonia will be required; therefore 127·2 grains of the salt will correspond to 17 grains of ammonia, or to 14 grains of nitrogen.

I may add, that the high atomic weight of the bisulphate (127·2) tends to diminish any errors from inaccurate weighing, or the presence of impurities.

5th, Two comparative analyses of pure uric acid were made at the same time; 6 grains gave, by Varrentrapp and Will's method, 31·90 of the platinum salt, = 33·4 per cent. of nitrogen; theory gives 33·33; 5 grains uric acid gave, by the bisulphate process, 33·376 per cent. of nitrogen; theory, 33·333.

Many other analyses have been made by this process in the University laboratory, and with the most satisfactory results, approaching in general more closely to the calculated quantities than by the method with bichloride of platinum.

It is obvious that the bisulphate of potash may be employed with advantage as a substitute for sulphuric acid in common alkalimetry, since it is easier to prepare a solution of the anhydrous bisulphate of any given strength than to obtain a standard dilute sulphuric acid.

2. An account of some Experiments on the Diet of Prisoners. By Professor Christison.

From careful experiments made, under direction of the Board of Directors of Prisons in Scotland, on 1624 prisoners confined in eight of the principal prisons, for periods not exceeding sixty days; and from an analysis of numerous observations on their weight and general health, the author arrives at the following conclusions:—

1. For the average of people whose occupation involves moderate muscular effort and no great exercise, a simple, well-selected sort of food, supplying seventeen ounces of daily real nutriment, of which four ounces are nitrogenous principles, constitutes a sufficient diet for maintaining health, strength, weight, and general condition; but less is not sufficient.

2. The proportion of nitrogenous nutriment in such a diet cannot

be very sensibly reduced below four ounces a-day without risk of injury.

3. This amount of nutriment, though in general adequate for the average in the supposed circumstances, is not always so.

4. It is probably inadequate for those who have been accustomed to a vigorous occupation in the open air, and a liberal dietary, even when their employment is changed for one involving no great muscular effort or exercise.

5. It is inadequate for a fair proportion of persons considerably exceeding the average in bulk.

6. It is inadequate for a considerable proportion of growing lads between sixteen and twenty.

7. It is more generally adequate for females than for males.

8. It is rendered occasionally inadequate by other causes not distinctly indicated by the observations in the Scottish prisons, but certainly independent of any increase in habitual muscular exertion.

9. Hence the economical regulation of the diet of bodies of men must always be a matter of great difficulty ; and if deviations from the standard dietary be not allowed with a liberal discretion, injury will be apt to ensue. And here it should be added from other observations, that suspicion may be lulled by no very perceptible injury except loss of weight occurring in ordinary seasons ; while, nevertheless, manifest injury will arise in periods of epidemic disease.

10. The prison dietary in Scotland has been very successfully adjusted by long experience in most of the prisons, so far as regards the class of prisoners who formed the subject of the preceding observations and experiments,—viz., those imprisoned for terms not exceeding two months. But in that dietary treacle-water cannot be substituted for milk without a reduction of flesh, the forerunner of probable ill health, unless some compensation be made in other articles of food. It has, in fact, been disallowed by the Board since these experiments were made.

11. In adjusting dietaries, and in all practical inquiries into the subject, reliance ought never to be put on practical observation alone ; but scientific analysis should be likewise brought into requisition. Numberless errors committed by merely practical men might easily be quoted, which could scarcely have escaped notice had they united scientific knowledge to practical skill.

3. Researches on some of the Crystalline Constituents of Opium. By Dr Thomas Anderson.

The author commenced his paper by referring to the numerous researches on opium which had already appeared, and stated that notwithstanding their number and extent, our information on the properties and composition of its various bases and indifferent constituents was still extremely imperfect. He had therefore submitted some of them to a renewed examination, employing as the source from which they were obtained the mother liquor of the manufacturers of muriate of morphia. By treatment of this liquor in a manner detailed in full in the paper, he obtained from it a large quantity of narcotine, and a certain proportion of thebaine and narceine.

Narceine was obtained in the form of extremely delicate needles, which mat together into a silky mass. It is soluble in water and alcohol, but not in ether. Potash and ammonia in moderately dilute solutions dissolve it more readily than water, but the addition of a large quantity of caustic potash causes its precipitation in shining scales. Concentrated sulphuric acid dissolves it in the cold, with an intense red colour, passing into green on the application of heat. Hydrochloric acid dissolves it entirely, but without producing the blue colour which, according to Pelletier, is characteristic of narceine. Narceine, though incapable of restoring the colour of reddened litmus, possesses feebly basic properties, and forms salts with the strong acids. Its analysis gave results corresponding with the formula $C_{46} H_{29} NO_{18}$, which was confirmed by the analysis of its platinum salt. The hydrochlorate, platinochloride, sulphate, and nitrate, are also described.

Thebaine crystallises in fine silvery plates. It is insoluble in water, but very soluble in alcohol and ether. It forms salts which cannot be obtained in crystals from their aqueous solution. It is insoluble in potash and ammonia. Strong sulphuric acid reacts upon it, and produces an intense blood-red colour even when entirely free from nitric acid. Sulphuric acid of specific gravity 1.300 dissolves it in the cold, but on heating a resinous semisolid mass is thrown down, which slowly dissolves in boiling water, and deposits on cooling a rather sparingly soluble salt in microscopic needles, which appears to be a product of decomposition.

Analysis shewed the composition of thebaine to be represented by the formula $C_{38} H_{21} NO_6$.

The Hydrochlorate of Thebaine is obtained by adding to thebaine an alcoholic solution of hydrochloric acid until the base is dissolved, excess being carefully avoided. On standing, the salt is deposited in fine rhomboidal crystals, often of considerable size. Their formula, when dried at 212° , is $C_{38} H_{21} NO_6 HCl + 2HO$.

Platinochloride of Thebaine is obtained as a yellow powder, slightly soluble in boiling water. The formula is $C_{38} H_{21} NO_6 HCl PtCl_2 + 2HO$.

The author then proceeds to detail the phenomena attendant on the action of nitric acid on *narcotine*. When concentrated nitric acid is added to narcotine, very violent action takes place, and a fluid is obtained which, on evaporation, yields an amorphous orange residue. When the acid is employed in a dilute state, and at a temperature not exceeding 120° , the narcotine slowly dissolves, and when the solution is complete, the fluid deposits a small quantity of a substance to which the author gives the name of *teropiammon*, and which is represented by the formula $C_{60} H_{29} NO_{26}$, and is derived from three equivalents of opianic acid and one of ammonia, minus the elements of four equivalents of water. The fluid which has deposited this substance contains *cotarnine*, which is precipitated by potash; and the potash solution contains, according to the extent to which the oxidation has gone, either opianic or hemipinic acid, or a third substance, to which the author gives the name of *opianyl*, and which is represented by the formula $C_{20} H_{10} O_8$. The author describes the properties of this substance and its hydrate. He then details the properties of certain compounds of opianic and hemipinic acids, from which he comes to the conclusion that the latter is a bibasic acid, and is correctly represented by the formula $C_{20} H_{10} O_{12}$. An acid potash salt, and an acid ether, hemipinovinic acid, are described.

The cotarnine, which is formed by the action of dilute nitric acid on narcotine, when treated with stronger acid, undergoes a further decomposition, and yields a variety of products, which are obviously the result of several different decompositions occurring simultaneously. The most abundant product of this action is a crystallisable acid possessing all the characters of Wöhler's apophyllic acid. It is best obtained by treating cotarnine with moderately strong

nitric acid, and then adding alcohol and ether, which throws down the new acid in small crystals. It is soluble in water, and by evaporation yields fine crystals. In alcohol and ether it is quite insoluble. It fuses at 401° , and dissolves readily in potash and soda. The composition was found to be represented by the formula $C_{16}H_7NO_8$, differing from that of anthranilic acid by the elements of two equivalents of carbonic acid.

Its salts are all highly soluble in water, and are with difficulty obtained in the crystalline form. Its silver salt can only be prepared by digesting the acid with oxide of silver, as when a neutral apophyllate is added to nitrate of silver a precipitate of a double nitrate and apophyllate of silver is obtained, which explodes when heated.

When the solution containing alcohol and ether, from which the apophyllic acid has been thrown down, is evaporated, and then distilled with potash, a volatile base is obtained, which possesses the composition and properties of methylamine, and under certain circumstances ethylamine also appears to be formed.

The following is a tabular statement of the substances examined in the paper.

Narceine,	$C_{46}H_{26}NO_{18}$
Hydrochlorate of narceine, .	$C_{46}H_{29}NO_{18}HCl$
Platinochloride of narceine,	$C_{46}H_{29}NO_{18}HClPtCl_2$
ROBIQUET'S narceine, . . .	$C_{32}H_{19}NO_{10} (?)$
Thebaine,	$C_{38}H_{21}NO_6$
Hydrochloride of thebaine,	$C_{38}H_{21}NO_6HCl + 2HO$
Platinochloride of thebaine,	$C_{38}H_{21}NO_6HClPtCl_2 + 2HO$
Teropiammon,	$C_{60}H_{29}NO_{26}$
Opianyl,	$C_{20}H_{10}O_{10}$
Hydrate of opianyl,	$C_{20}H_{10}O_8 + HO$
Opianic acid,	$C_{20}H_{10}O_{10}$
Opianic ether,	$C_4H_5O, C_{20}H_9O_9$
Hemipinic acid,	$C_{20}H_{10}O_{12}$
Acid hemipinate of potass, .	$KOHO C_{20}H_8O_{10}$
Hemipinate of silver, . . .	$2AgO C_{20}H_8O_{10}$
Hemipinovinic acid,	$HO C_4H_5O C_{20}H O_{10}$
Apophyllic acid,	$C_{16}H_7NO_8$
Apophyllate of silver, . . .	$AgO C_1H_6NO_7$
Methylamine,	C_2H_5N
Ethylamine,	C_4H_7N

4. On the Red Prominences seen during Total Eclipses of the Sun. Part I. By William Swan, F.R.S.E.

The object of this communication is to discuss the evidence afforded by various observations of the eclipse which occurred on the 28th July 1851, as to the nature of the rose-coloured prominences which are seen round the moon during the total phase of solar eclipses.

In order to render the inquiry into the nature of the red prominences as complete as possible, the author has not confined himself to the consideration of such hypotheses only as have been formally stated regarding them; but has also included in his examination such other views as he thought might probably be entertained regarding those remarkable objects.

The observations of the eclipse discussed by the author are chiefly contained in the Royal Astronomical Society's Notice for January 1852, and the following are the conclusions to which he has been led by the examination of those observations:—

1. The red prominences were not caused by the telescopes used in viewing the eclipse; for they were seen by the naked eye.

2. The red prominences cannot be regarded as optical phenomena, produced either by unequally heated air, as supposed by M. Faye, or by the action of the moon's limb on the sun's light; for these hypotheses are inconsistent both with the permanency of form displayed by the prominences, and with the general similarity of their appearance, as seen from stations differently situated with reference to the line of central eclipse.

3. While the optical hypotheses thus labour under difficulties peculiar to themselves, the objections to the opinion that the red prominences are *material* objects existing in the sun, founded on the discrepancies in the observations, as to their number, forms, and positions, are found to apply with equal force to the optical hypotheses.

4. Little care seems, in some instances, to have been taken in ascertaining the positions of the red prominences, and accordingly great discrepancies occur among the observations; while in certain cases they agreed remarkably well. Mr Dawes and the author, who both used means for obtaining an accurate estimation of angles of

position, differ by less than a degree in the place they assign to the most conspicuous prominence seen at the late eclipse, and they also assign to it almost exactly the same form. This, and other coincidences between observations made at distant stations, are strongly in favour of the idea that the prominences are material objects.

5. The observed differences in the numbers and positions of the red prominences, as seen from stations differently situated in the moon's shadow, are, upon the whole, accordant with the effects which parallax would produce, if the prominences actually existed in the sun.

6. The hypothesis that the prominences exist in the sun seems to afford the only explanation of the fact, that the moon gradually occulted them on the side towards which it moved, and exposed them on the other, while at the same time the outlines of those portions of the prominences which continued visible, as well as their relative positions, remained unaltered.

7. On these grounds it is inferred that the red prominences are *material* objects existing on the sun.

The following Gentleman was duly elected an Ordinary Fellow :—

JAMES WILLIAM GRANT, Esq. of Elchies.

The following Donations to the Library were announced :—

The Assurance Magazine. No. 5. 8vo.—*From the Institute of Actuaries.*

Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou. Tome IX. 4to.

Bulletin de la Société Impériale des Naturalistes de Moscou. 1851. No. 2. 8vo.—*From the Society.*

Monday, 19th April 1852.

DR CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. On the Red Prominences seen during Total Eclipses of the Sun. Part II. By William Swan, F.R.S.E.

In the first part of this paper, the author endeavoured to shew,

from a comparison of various observations of the red prominences seen at the eclipse of the 28th July 1851, that those objects were not mere optical phenomena, but that they actually existed in the sun.

The object of the present communication is to offer some conjectures regarding the nature of the red prominences, and their possible connection with other solar phenomena.

The comparatively faint light reflected by the prominences, their overhanging forms, and the appearance at the late eclipse, of a prominence completely detached from the moon's limb, all conspire to prove that they are cloudy masses floating in the sun's atmosphere; while the existence of a long range of red prominences, which, at certain stations, was seen extending over nearly a third part of the moon's limb, together with their tolerably uniform distribution all round the rest of the moon's edge, prove that the matter composing them is very copiously diffused through the sun's atmosphere.

To account for the existence of the red prominences, the author supposes that the sun's luminous atmosphere is surrounded by an *envelope of cloudy matter*, capable of absorbing part of his light, and reflecting chiefly the red rays of the spectrum—a conjecture which is founded both on the observed general distribution of the red prominences, and on the appearance of a band of red light just before the end of the total phase of the eclipse, which was seen extending round the moon's limb, about the point where the sun emerged. The serrated outline of the long range of prominences indicates that the surface of the stratum of cloud is exceedingly uneven, and its higher portions seen beyond the edge of the moon, may constitute red prominences. It is also however supposed, that just as the spots on the sun have been conceived to arise from upward currents in the solar atmosphere, removing portions of its luminous stratum; the same, or similar currents, may penetrate the superincumbent stratum of cloud, carry upwards the edges of the aperture it has formed, and detach masses of cloud, so as to form higher and more remarkable prominences, like the more striking objects of that kind which were seen at the late eclipse.

The author conceives that this view regarding the nature of the red prominences, may also serve to explain other solar phenomena.

1. The darkness of the sun's edge, compared with his centre, is generally attributed to the absorbent action of the solar atmosphere on light; but unless the thickness of the absorbent atmosphere be

small, when compared with the sun's diameter, the difference of its action on the central and lateral rays would be insensible. On the other hand, the wide extension of the corona indicates that the sun's atmosphere is of great thickness compared with his diameter; and there is, therefore, difficulty in supposing the darkness of the sun's edges to arise from the *general* absorption of light by his atmosphere. That phenomenon, however, is easily explained by supposing it to arise from the absorbent action of a comparatively thin stratum of cloud surrounding the sun.

2. The faculæ are generally understood to be ridges in the sun's luminous atmosphere; but the author supposes them to be apertures in the envelope of cloud, through which his rays pass more freely than elsewhere. The greater distinctness of the faculæ when seen near the sun's limb, is explained by the light shining through the apertures being there contrasted with light which has suffered absorption by passing obliquely through the envelope of cloud; while towards the centre the contrast is not so great, as the light passes nearly perpendicularly through the envelope, and is therefore less absorbed.

3. The supposition that the larger prominences are situated on the edges of apertures in the envelope of cloud is consistent with the increased brightness of the corona in their neighbourhood, which was observed at the late eclipse.

4. The existence of an envelope of cloud surrounding the sun, capable of absorbing light, but penetrated by apertures, and therefore transmitting light more freely at certain places than at others, may serve to explain the great want of uniformity in the brightness of the corona, and the brilliant beams of light which occur in it at certain points.

The hypothesis that an envelope of cloud surrounds the sun, thus refers to one physical cause, a variety of solar phenomena, namely, the darkness of the sun's limb compared with his centre, the existence of faculæ on his disc, the discontinuous illumination of the corona, the existence of the red prominences, and the occasional increased brightness of the corona in their neighbourhood.

The idea that a cloudy envelope surrounds the sun, occurred to the author immediately after witnessing the eclipse of 28th July 1851, when he reflected on the striking want of uniformity he had observed in the illumination of the corona.

That phenomenon strongly impressed on him the conviction, that something existed at the surface of the sun which intercepted his light, more at certain points than at others; and he conceived that the matter composing the red prominences, might be the absorbent medium which produced that effect.

2. On a Universal Tendency in Nature to the Dissipation of Mechanical Energy. By Professor William Thomson.

The object of the present communication is to call attention to the remarkable consequences which follow from Carnot's proposition, established as it is on a new foundation, in the dynamical theory of heat; that there is an absolute waste of mechanical energy available to man, when heat is allowed to pass from one body to another at a lower temperature, by any means not fulfilling his criterion of a "perfect thermo-dynamic engine." As it is most certain that Creative Power alone can either call into existence or annihilate mechanical energy, the "waste" referred to cannot be annihilation, but must be some transformation of energy.* To explain the nature of this transformation, it is convenient, in the first place, to divide *stores* of mechanical energy into two classes—*statical* and *dynamical*. A quantity of weights at a height, ready to descend and do work when wanted, an electrified body, a quantity of fuel, contain stores of mechanical energy of the statical kind. Masses of matter in motion, a volume of space through which undulations of light or radiant heat are passing, a body having thermal motions among its particles (that is, not infinitely cold), contain stores of mechanical energy of the dynamical kind.

The following propositions are laid down regarding the *dissipation* of mechanical energy from a given store, and the *restoration* of it to its primitive condition. They are necessary consequences of the axiom, "*It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects.*" (*Dynam. Th. of Heat*, § 12.)

I. When heat is created by a reversible process, (so that the mechanical energy thus spent may be *restored* to its primitive con-

* See the Author's previous paper on the Dynamical Theory of Heat, § 22.

dition,) there is also a transference from a cold body to a hot body of a quantity of heat bearing to the quantity created a definite proportion depending on the temperatures of the two bodies.

II. When heat is created by any unreversible process (such as friction,) there is a *dissipation* of mechanical energy, and a full *restoration* of it to its primitive condition is impossible.

III. When heat is diffused by *conduction*, there is a *dissipation* of mechanical energy, and perfect *restoration* is impossible.

IV. When radiant heat or light is absorbed, otherwise than in vegetation, or in chemical action, there is a *dissipation* of mechanical energy, and perfect *restoration* is impossible.

In connection with the second proposition, the question, *How far is the loss of power experienced by steam in rushing through narrow steam-pipes compensated, as regards the economy of the engine, by the heat* (containing an exact equivalent of mechanical energy) *created by the friction?*—is considered; and the following conclusion is arrived at:—

Let S denote the temperature of the steam, (which is nearly the same in the boiler and steam-pipe, and in the cylinder till the expansion within it commences); T the temperature of the condenser; μ the value of Carnot's function for any temperature, t ; and R the value of

$$-\frac{1}{J} \int_T^S \mu dt.$$

Then $(1 - R)w$ expresses the greatest amount of mechanical effect that can be economised, in the circumstances, from a quantity $\frac{1}{J}w$ of heat produced by the expenditure of a quantity, w , of work in friction, whether of the steam in the pipes and entrance-ports, or of any solids or fluids in motion in any part of the engine; and the remainder, Rw , is absolutely and irrecoverably wasted, unless some use is made of the heat discharged from the condenser. The value of $1 - R$ has been shewn to be not more than about one-fourth for the best steam-engines, and we may infer that in them at least three-fourths of the work spent in any kind of friction is utterly wasted.

In connection with the third proposition, the quantity of work that could be got by equalising the temperature of all parts of a solid body possessing initially a given non-uniform distribution of heat, if this could be done by means of perfect thermo-dynamic engines

without any conduction of heat, is investigated. If t be the initial temperature (estimated according to any arbitrary system) at any point xyz of the solid, T the final uniform temperature, and c the thermal capacity of unity of volume of the solid, the required mechanical effect is of course equal to

$$J \iiint c (t - T) dx dy dz,$$

being simply the mechanical equivalent of the amount of heat put out of existence. Hence the problem becomes reduced to that of the determination of T . The following solution is obtained,—

$$T = \frac{\iiint \epsilon^{-\frac{1}{J} \int_0^t \mu dt} c t dx dy dz}{\iiint \epsilon^{-\frac{1}{J} \int_0^t \mu dt} c dx dy dz}.$$

If the system of thermometry adopted* be such that $\mu = \frac{J}{t + \alpha}$, that is, if we agree to call $\frac{J}{\mu} - \alpha$ the *temperature* of a body, for which μ is the *value of Carnot's function*, (α and J being constants,) the preceding expression becomes

$$T = \frac{\iiint c dx dy dz}{\iiint \frac{c}{t + \alpha} dx dy dz} - \alpha.$$

The following general conclusions are drawn from the propositions stated above, and known facts with reference to the mechanics of animal and vegetable bodies:—

1. There is at present in the material world a universal tendency to the dissipation of mechanical energy.

2. Any *restoration* of mechanical energy, without more than an equivalent of dissipation, is impossible in inanimate material processes, and is probably never effected by means of organised matter,

* According to "Mayer's hypothesis," this system coincides with that in which equal differences of temperature are defined as those with which the same mass of air under constant pressure has equal differences of volume, provided J be the mechanical equivalent of the thermal unit and $\frac{1}{\alpha}$ the coefficient of expansion of air.—See the author's previous paper "On the Heat produced by the Compression of a Gas," &c., § 5.

either endowed with vegetable life, or subjected to the will of an animated creature.

3. Within a finite period of time past the earth must have been, and within a finite period of time to come the earth must again be, unfit for the habitation of man as at present constituted, unless operations have been, or are to be performed, which are impossible under the laws to which the known operations going on at present in the material world are subject.

3. On Rifle Cannon. By Captain Davidson, Bombay Army.
Communicated by Professor C. Piazzzi Smyth.

This paper was written in India as far back as 1839, but many of its suggestions were still untried, and present circumstances seem to urge their importance.

The recent improvements in the hand-rifle have so greatly increased the practical range of that instrument, as to have passed and left far behind, in point of range and precision, the heavy field pieces which heretofore have done accurate execution at distances impracticable to small arms. The large guns therefore imperatively require to undergo the same alteration which, by converting the musket into a rifle, has so greatly increased the directness and accuracy of the flight of its ball.

Rifling has already been tried on cannon, but not with success; and Captain Davidson's paper merely professed to give an improved method of applying the principle. This he effected by inserting into the sides of the shot or shell, ribs of wood, to fit into the rifle grooves of the bore. In this way he considered that the necessary rotation would be given to the ball, without the usual error of tearing and destroying the figure of the interior of the gun; the soft wooden ribs, and not the hard cast-iron of the Captain's projectiles, alone coming into contact with the bore,

To this method of rifles he proposed also to join the conical form for the projectile, fired with the *small end* first, and to make the shells self-exploding, by a percussion cap on the extremity.

Having entered somewhat into the principle and history of rifle pieces, the Captain gives the concluding portion of the pamphlet on the same subject by Mr Robins, the Newton of gunnery, as valuable in itself, and strangely unattended to through more than half a century.

" I shall therefore close this paper (Mr Robins' words) with predicting, that whatever state shall thoroughly comprehend the nature and advantages of rifled barrel pieces, and, having facilitated and completed their construction, shall introduce into their armies their general use, with a dexterity in the management of them ; they will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will perhaps fall little short of the wonderful effects which histories relate to have been formerly produced by the first inventors of fire-arms."

4. On two New Processes for the detection of Fluorine when accompanied by Silica, and on the presence of Fluorine in Granite, Trap, and other Igneous Rocks, and in the Ashes of Recent and Fossil Plants. By Dr George Wilson.

The author, after alluding to his previous communications to the Society in reference to fluorine, stated that he had always attributed the slight indications of the presence of this element in plants, which his own investigations and those of others had yielded, to the amount of silica which was contained in vegetable ashes. The presence of silica, which throws special difficulties in the way of detecting fluorine, had also prevented him from seeking for it in trap rocks and other mineral masses. Recently, however, he had put in practice two processes, which were applicable to all bodies containing silica and a metallic fluoride, which are decomposed by boiling oil of vitriol. When this acid is heated along with a silicated fluoride, it occasions an evolution of the fluorine in combination with silicon, as the well-known gaseous fluoride of silicon (Si F_3). In the first process, this gas is conducted into a solution of caustic potash, in which it occasions a precipitate of the fluoride of silicon and potassium ($2 \text{ Si F}_3 + 3 \text{ K F}$). This precipitate is heated in a metallic crucible with potassium, so as to separate the silicon, and convert the double fluoride into fluoride of potassium. When moistened with oil of vitriol, it evolves hydrofluoric acid, the escape of which is easily recognised by its etching glass. This process gave good results, but was tedious, and sometimes unsuccessful. It was accordingly abandoned for the

second process, in which ammonia is substituted for potass, and the use of potassium is dispensed with.

The following are the steps of the ammonia process. The silicated fluoride, such as trap-rock or the ashes of straw, is heated with oil of vitriol, and the fluoride of silicon which is given off is conducted by a bent tube into an aqueous solution of ammonia, with which it forms the fluoride of silicon and ammonium ($2 \text{Si F}_3 + 3 \text{NH}_4 \text{F}$). When this is evaporated to perfect dryness, the silicon becomes insoluble silica, from which water dissolves out the pure fluoride of ammonium. This ammonio-fluoride is dried up in a platina crucible, and after moistening the residue with sulphuric acid, a piece of waxed glass, with lines traced through the wax down to the glass, is laid as a cover on the crucible, so as to permit the hydrofluoric acid evolved to etch the lines.

This process has been tried with Peterhead and Aberdeen granite, with basalt from Arthur's Seat, greenstone from Corstorphine Hill, and clinkstone from Blackford Hill, all in the neighbourhood of Edinburgh. It has also been tried with the ashes of barley-straw, of hay, of coal, and of charcoal; and in addition, with a fossil bone containing much carbonate of lime; and with the deposit from the boiler of an ocean steamer. To the bone, and to the boiler deposit, pounded glass was added. Most of the specimens obtained in this way were shewn to the Society. These, the author stated, were not selected successful ones, but represented the earliest trials. Where the rocks under examination had been weathered, or the substances, such as plant-ashes, contained salts of volatile acids, as chlorides and carbonates, they were treated, first, with oil of vitriol, *in the cold*, so as to evolve hydrochloric acid and carbonic acid. On afterwards raising the liquid to the boiling point, in a flask with a bent tube, a gas was given off, if fluorine were present, which deposited gelatinous silica when passed through water, and produced with it a solution which gave a gelatinous precipitate with potash. The whole of the fluoride of silicon is given off as soon as the oil of vitriol has reached its boiling point. The author is at present engaged in applying this process to a variety of substances, and in ascertaining its applicability to the quantitative determination of fluorine.

In conclusion, it was noticed that the discovery of fluorine in trap and granite, threw much light on the production of minerals, such as fluor spar and crystallised silica, which are found in these rocks;

and that the detection of the element under notice in marked quantity in plants, prepares us for the recognition of fluorine as a constant ingredient of the tissues of animals, who receive it both in their solid food, and in the water which they drank. The author, however, forbore to enlarge, upon the application of his discovery of the wide distribution of fluorine, till he analysed an additional number of substances for it.

The following Donations to the Library were announced :—

The Nature and Treatment of Diseases of the Heart. By James Wardrop, M.D. 8vo.—*From the Author.*

Twentieth Report of the Scarborough Philosophical Society.—8vo.—*From the Society.*

Minutes of Proceedings of the Institution of Civil Engineers. 1849-50—1850-51. 8vo.

List of Members of Ditto.—*From the Institution.*

Assurance Magazine. No. 7. 8vo.

Constitution and Laws of the Institute of Actuaries of Great Britain and Ireland. 8vo.—*From the Institute.*

Transactions of the Cambridge Philosophical Society. Vol. IX. Part 2. 8vo.—*From the Society.*

The American Journal of Science and Arts. Second Series. No. 38. 8vo.—*From the Editors.*

Flora Batava. Aflevering 168. 4to. — *From the King of Holland.*

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OF THE

ROYAL SOCIETY OF EDINBURGH.

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